Riverside County
Perris, California

SPECIFICATION NO. 1388W

EUCALYPTUS BOOSTER PUMP STATION
VOLUME II of II

Work Order # 419648

A PUBLIC WORKS PROJECT

Contents:
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Paul D. Jones, II, P.E. - General Manager

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Eastern Municipal Water District

Visit our website at www.emwd.org to view currently advertised projects
Navigate to Construction ➔ Construction Bid Opportunities
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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 film-forming water-repellent coatings for the following vertical and horizontal surfaces:

1. Concrete (unpainted).
2. Concrete unit masonry (unpainted and unglazed).

B. Related Sections include the following:

1. Division 03 Section "Cast-in-Place Concrete" for curing compounds, curing and sealing compounds, and penetrating liquid floor treatments.
2. Division 04 Section "Unit Masonry" for integral water-repellent admixture for unit masonry assemblies.
3. Division 07 Section "Joint Sealants."
4. Division 09 painting Sections for paints and coatings.

1.3 PERFORMANCE REQUIREMENTS

A. Performance Testing: Provide water repellents that comply with test-performance requirements indicated, as evidenced by reports of tests performed by manufacturer by a qualified independent testing agency on manufacturer's standard products applied to substrates simulating those on Project using same application methods to be used for Project.

B. Absorption: Minimum 90 percent reduction of absorption after 24 hours in comparison of treated and untreated specimens.

1. Hardened Concrete: ASTM C 642.

C. Water-Vapor Transmission: Maximum 10 percent reduction in rate of vapor transmission in comparison of treated and untreated specimens, per ASTM E 96.
D. Permeability: Minimum 80 percent water-vapor transmission in comparison of treated and untreated specimens, per ASTM D 1653.

E. Durability: Maximum 5 percent loss of water repellency after 2500 hours of weathering in comparison to specimens before weathering, per ASTM G 154.

F. Chloride-Ion Intrusion in Concrete: NCHRP Report 244, Series II tests.
   1. Reduction of Water Absorption: 81 percent.
   2. Reduction in Chloride Content: .75 percent.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.
   1. Include manufacturer's printed statement of VOC content.
   2. Include manufacturer's standard colors.

B. Samples: For each type of water repellent and substrate indicated, 12 by 12 inches (300 by 300 mm) in size, with specified water-repellent treatment applied to half of each Sample.

C. Manufacturer Certificates: Signed by manufacturers certifying that water repellents comply with requirements.

D. Qualification Data: For Installer.

E. Preconstruction Testing Reports: For water-repellent-treated substrates.

F. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for assemblies.

G. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer.

B. Testing Agency Qualifications: An independent agency qualified according to ASTM E 548 for testing indicated.

C. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."
1.6 PROJECT CONDITIONS

A. Limitations: Proceed with application only when the following existing and forecasted weather and substrate conditions permit water repellents to be applied according to manufacturers' written instructions and warranty requirements:

1. Ambient temperature is above 50 deg F.
2. Concrete surfaces and mortar have cured for more than 28 days.
3. Concrete or masonry walls are not treated prior to 30 days after building close-in.
4. Rain or snow is not predicted within 24 hours.
5. Application proceeds more than 24 hours after surfaces have been wet.
6. Application proceeds more than seven days after concrete has been cured at 75 degrees F.
7. Substrate is not frozen, or surface temperature is above 50 deg F.
8. Windy conditions do not exist that may cause water repellent to be blown onto vegetation or surfaces not intended to be treated.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer and Applicator agree(s) to repair or replace materials that fail to maintain water repellency specified in Part 1 "Performance Requirements" Article within specified warranty period.

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products listed in other Part 2 articles.

B. Products: Subject to compliance with requirements, provide one of the products listed in other Part 2 articles.
2.2 FILM-FORMING WATER REPELLENTS

A. Acrylic, Film-Forming Water Repellent: Clear, breathing coating of acrylic resins; with a water-based, solvent-based, or acrylic emulsion solution containing less than 15 percent solids by volume; and with .4 lb/gal. or less of VOCs.

1. Products:
   a. ChemMasters; Enviropel Methacrylate.
   b. Hydrozo, a division of ChemRex; Colorsil.
   d. Sherwin Williams; Sher-Crete

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean substrate of substances that might interfere with penetration or performance of water repellents. Test for moisture content, according to water-repellent manufacturer's written instructions, to ensure that surface is dry enough.

1. Cast-in-Place Concrete: Remove oil, curing compounds, laitance, and other substances that could prevent adhesion or penetration of water repellents.

B. Test for pH level, according to water-repellent manufacturer's written instructions, to ensure chemical bond to silicate minerals.

C. Protect adjoining work, including sealant bond surfaces, from spillage or blow-over of water repellent. Cover adjoining and nearby surfaces of aluminum and glass if there is the possibility of water repellent being deposited on surfaces. Cover live plants and grass.

D. Coordination with Sealants: Do not apply water repellent until sealants for joints adjacent to surfaces receiving water-repellent treatment have been installed and cured.

1. Water-repellent work may precede sealant application only if sealant adhesion and compatibility have been tested and verified using substrate, water repellent, and sealant materials identical to those used in the work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 APPLICATION

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect the substrate before application of water repellent and to instruct Applicator on the product and application method to be used.

B. Apply a heavy-saturation spray coating of water repellent on surfaces indicated for treatment using low-pressure spray equipment. Comply with manufacturer's written instructions for using airless spraying procedure, unless otherwise indicated.

C. Apply a second saturation spray coating, repeating first application. Comply with manufacturer's written instructions for limitations on drying time between coats and after rainstorm wetting of surfaces between coats. Consult manufacturer's technical representative if written instructions are not applicable to Project conditions.

3.3 CLEANING

A. Immediately clean water repellent from adjoining surfaces and surfaces soiled or damaged by water-repellent application as work progresses. Repair damage caused by water-repellent application. Comply with manufacturer's written cleaning instructions.

END OF SECTION 071900
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 the following:
   1. Exposed building insulation.

B. Related Sections include the following:
   1. Division 06 Section "Sheathing" for sheathing over wood framing.

1.3 DEFINITIONS

A. Mineral-Fiber Insulation: Insulation composed of rock-wool fibers, slag-wool fibers, or glass fibers; produced in boards and blanket with latter formed into batts (flat-cut lengths) or rolls.

1.4 SUBMITTALS

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

B. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency for insulation products.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of building insulation through one source from a single manufacturer.

B. Fire-Test-Response Characteristics: Provide insulation and related materials with the fire-test-response characteristics indicated, as determined by testing identical products per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect insulation materials from physical damage and from deterioration by moisture, soiling, and other sources. Store inside and in a dry location. Comply with manufacturer's written instructions for handling, storing, and protecting during installation.

B. Protect plastic insulation as follows:
   1. Do not expose to sunlight, except to extent necessary for period of installation and concealment.
   2. Protect against ignition at all times. Do not deliver plastic insulating materials to Project site before installation time.
   3. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
   2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 GLASS-FIBER BLANKET INSULATION

A. Available Manufacturers:
   1. CertainTeed Corporation.
   2. Guardian Fiberglass, Inc.
   4. Knauf Fiber Glass.
   5. Owens Corning.
B. Faced, Glass-Fiber Blanket Insulation: ASTM C 665, Type III (blankets with reflective membrane facing), Class A (membrane-faced surface with a flame-spread index of 25 or less); Category 1 (membrane is a vapor barrier), faced with polypropylene-scrim-kraft vapor-retarder membrane on 1 face.

C. Where glass-fiber blanket insulation is indicated by the following thicknesses, provide blankets in batt or roll form with thermal resistances indicated:

1. Application: Thermal insulation below exterior roof
2. Thickness: As required to meet a minimum R value of R-30.

2.3 AUXILIARY INSULATING MATERIALS

A. Vapor-Retarder Tape: Pressure-sensitive tape of type recommended by insulation manufacturers for sealing joints and penetrations in vapor-retarder facings.

B. Adhesive for Bonding Insulation: Product with demonstrated capability to bond insulation securely to substrates indicated without damaging insulation and substrates.

2.4 INSULATION FASTENERS

A. Adhesively Attached, Angle-Shaped, Spindle-Type Anchors: Angle welded to projecting spindle; capable of holding insulation of thickness indicated securely in position indicated with self-locking washer in place; and complying with the following requirements:

1. Available Products:
   a. Gemco; 90-Degree Insulation Hangers.

2. Angle: Formed from 0.030-inch- (0.762-mm-) thick, perforated, galvanized carbon-steel sheet with each leg 2 inches (50 mm) square.

3. Spindle: Copper-coated, low carbon steel; fully annealed; 0.105 inch (2.67 mm) in diameter; length to suit depth of insulation indicated.

B. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized steel sheet, with beveled edge for increased stiffness, sized as required to hold insulation securely in place, but not less than 1-1/2 inches (38 mm) square or in diameter.

1. Available Products:
   a. AGM Industries, Inc.; RC150.
b. AGM Industries, Inc.; SC150.
c. Gemco; Dome-Cap.
d. Gemco; R-150.
e. Gemco; S-150.

2. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap.

C. Anchor Adhesive: Product with demonstrated capability to bond insulation anchors securely to substrates indicated without damaging insulation, fasteners, and substrates.

1. Available Products:
   a. AGM Industries, Inc.; TACTOO Adhesive.
   b. Eckel Industries of Canada; Stic-Klip Type S Adhesive.
   c. Gemco; Tuff Bond Hanger Adhesive.

**PART 3 - EXECUTION**

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements of Sections in which substrates and related work are specified and for other conditions affecting performance.

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

3.2 PREPARATION

A. Clean substrates of substances harmful to insulation or vapor retarders, including removing projections capable of puncturing vapor retarders or of interfering with insulation attachment.

3.3 INSTALLATION, GENERAL

A. Comply with insulation manufacturer's written instructions applicable to products and application indicated.

B. Install insulation that is undamaged, dry, and unsoiled and that has not been left exposed at any time to ice, rain, and snow.
C. Extend insulation in thickness indicated to envelop entire area to be insulated. Cut and fit tightly around obstructions and fill voids with insulation. Remove projections that interfere with placement.

D. Apply insulation units to substrates by method indicated, complying with manufacturer's written instructions. If no specific method is indicated, bond units to substrate with adhesive or use mechanical anchorage to provide permanent placement and support of units.

3.4 PROTECTION

A. Protect installed insulation from damage due to harmful weather exposures, physical abuse, and other causes. Provide temporary coverings or enclosures where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

END OF SECTION 07210
SECTION 07311
ASPHALT SHINGLES

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. Asphalt shingles.
   2. Underlayment.

B. Related Sections:
   1. Division 06 Section "Rough Carpentry" for wood framing.
   2. Division 07 Section "Sheet Metal Flashing and Trim" for metal roof penetration flashings counterflashings and flashings.

1.3 DEFINITION

A. Roofing Terminology: See ASTM D 1079 and glossary of NRCA's "The NRCA Roofing and Waterproofing Manual" for definitions of terms related to roofing work in this Section.

1.4 SUBMITTALS

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

B. Samples for Verification: For the following products, of sizes indicated, to verify color selected:
   1. Asphalt Shingle: Full size.
   2. Ridge and Hip Cap Shingles: Full size.
   3. Self-Adhering Underlayment: 12 inches (300 mm) square.

C. Qualification Data: For qualified Installer.
D. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for asphalt shingles.

E. Research/Evaluation Reports: For each type of asphalt shingle required, from the ICC.

F. Maintenance Data: For each type of asphalt shingle to include in maintenance manuals.

G. Warranties: Sample of special warranties.

1.5 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 ridge and hip cap shingles felt underlayment and self-adhering sheet underlayment from single source from single manufacturer.

C. Fire-Resistance Characteristics: Where indicated, provide asphalt shingles and related roofing materials identical to those of assemblies tested for fire resistance per test method below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify products with appropriate markings of applicable testing agency.

1. Exterior Fire-Test Exposure: Class A; ASTM E 108 or UL 790, for application and roof slopes indicated.

D. Preinstallation Conference: Conduct conference at Project site.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store roofing materials in a dry, well-ventilated, weathertight location according to asphalt shingle manufacturer's written instructions. Store underlayment rolls on end on pallets or other raised surfaces. Do not double stack rolls.

1. Handle, store, and place roofing materials in a manner to avoid significant or permanent damage to roof deck or structural supporting members.

B. Protect unused underlayment from weather, sunlight, and moisture when left overnight or when roofing work is not in progress.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install asphalt shingles until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and temporary
HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1. Install self-adhering sheet underlayment within the range of ambient and substrate temperatures recommended by manufacturer.

1.8 WARRANTY

A. Special Warranty: Standard form in which manufacturer agrees to repair or replace asphalt shingles that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Manufacturing defects.
   b. Structural failures including failure of asphalt shingles to self-seal after a reasonable time.

2. Material Warranty Period: 40 years from date of Substantial Completion, prorated, with first twenty years nonprorated.
3. Wind-Speed Warranty Period: Asphalt shingles will resist blow-off or damage caused by wind speeds up to 80 mph (36 m/s) for five years from date of Substantial Completion.
4. Algae-Discoloration Warranty Period: Asphalt shingles will not discolor five years from date of Substantial Completion.
5. Workmanship Warranty Period: 10 years from date of Substantial Completion.

B. Special Project Warranty: Roofing Installer's Warranty, or warranty form at end of this Section, signed by roofing Installer, covering the Work of this Section, in which roofing Installer agrees to repair or replace components of asphalt shingle roofing that fail in materials or workmanship within specified warranty period.

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

1.9 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Asphalt Shingles: 100 sq. ft (9.3 sq. m) of each type, in unbroken bundles.
PART 2 - PRODUCTS

2.1 GLASS-FIBER-REINFORCED ASPHALT SHINGLES


1. Basis-of-Design Product: Subject to compliance with requirements, provide Duration Premium Shingles manufactured by Owings Corning or comparable product by one of the following:
   b. CertainTeed Corporation.
   c. Elk Premium Building Products, Inc.; an ElkCorp company.
   d. Emco Building Products Corp.
   e. GAF Materials Corporation.
   f. IKO.
   g. Malarkey Roofing Products.
   h. Owens Corning.
   i. PABCO Roofing Products.
   j. TAMKO Roofing Products, Inc.

2. Strip Size: Manufacturer's standard.
3. Algae Resistance: Granules treated to resist algae discoloration.
4. Color and Blends: As selected by Architect from manufacturer's full range.

2.2 UNDERLAYMENT MATERIALS

A. Felt: ASTM D 226 or ASTM D 4869, Type II, 30lb asphalt-saturated organic felts, nonperforated.

B. Self-Adhering Sheet Underlayment, Granular Surfaced: ASTM D 1970, minimum of 55-mil- (1.4-mm-) thick sheet; glass-fiber-mat-reinforced, SBS-modified asphalt; mineral-granule surfaced; with release paper backing; cold applied.

1. 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:
   a. ALCO-NVC Inc.
   c. Carlisle Coatings & Waterproofing, Inc.
Asphalt Shingles
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d. CertainTeed Corporation.
e. GAF Materials Corporation.
f. Henry Company.
g. IKO.
h. Johns Manville.
i. Owens Corning.

2.3 ACCESSORIES

A. Asphalt Roofing Cement: ASTM D 4586, Type II, asbestos free.

B. Roofing Nails: ASTM F 1667; aluminum, stainless-steel, copper, or hot-dip galvanized-steel wire shingle nails, minimum 0.120-inch- (3-mm-) diameter, smooth Shank, sharp-pointed, with a minimum 3/8-inch- (9.5-mm-) diameter flat head and of sufficient length to penetrate 3/4 inch (19 mm) into solid wood decking or extend at least 1/8 inch (3 mm) through OSB or plywood sheathing.

1. Where nails are in contact with metal flashing, use nails made from same metal as flashing.

C. Felt Underlayment Nails: Aluminum, stainless-steel, or hot-dip galvanized-steel wire with low-profile capped heads or disc caps, 1-inch (25-mm) minimum diameter.

2.4 METAL FLASHING AND TRIM

A. General: Comply with requirements in Division 07 Section "Sheet Metal Flashing and Trim."


B. Fabricate sheet metal flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of the item.

1. Drip Edges: Fabricate in lengths not exceeding 10 feet (3 m) with 2-inch (50-mm) roof-deck flange and 1-1/2-inch (38-mm) fascia flange with 3/8-inch (9.6-mm) drip at lower edge.

C. Vent Pipe Flashings: ASTM B 749, Type L51121, at least 1/16 inch (1.6 mm) thick. Provide lead sleeve sized to slip over and turn down into pipe, soldered to skirt at slope of roof, and extending at least 4 inches (100 mm) from pipe onto roof.
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.

1. Examine roof sheathing to verify that sheathing joints are supported by framing and blocking or metal clips and that installation is within flatness tolerances.
2. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and completely anchored; and that provision has been made for flashings and penetrations through asphalt shingles.

B. 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: Comply with underlayment manufacturer's written installation instructions applicable to products and applications indicated unless more stringent requirements apply.

B. Single-Layer Felt Underlayment: Install on roof deck parallel with and starting at the eaves. Lap sides a minimum of 2 inches (50 mm) over underlying course. Lap ends a minimum of 4 inches (100 mm). Stagger end laps between succeeding courses at least 72 inches (1830 mm). Fasten with felt underlayment roofing nails.

1. Install felt underlayment on roof deck not covered by self-adhering sheet underlayment. Lap sides over self-adhering sheet underlayment not less than 3 inches (75 mm) in direction to shed water. Lap ends of felt not less than 6 inches (150 mm) over self-adhering sheet underlayment.

2. Install fasteners at no more than 36 inch (900 mm) o.c.

C. Self-Adhering Sheet Underlayment: Install, wrinkle free, on roof deck. Comply with low-temperature installation restrictions of underlayment manufacturer if applicable. Install at locations indicated on Drawings, lapped in direction to shed water. Lap sides not less than 3-1/2 inches (89 mm). Lap ends not less than 6 inches (150 mm) staggered 24 inches (600 mm) between courses. Roll laps with roller. Cover underlayment within seven days.
1. Prime concrete and masonry surfaces to receive self-adhering sheet underlayment.
2. Eaves: Extend from edges of eaves 24 inches (600 mm) beyond interior face of exterior wall.
3. Hips: Extend 18 inches (450 mm) on each side.
4. Ridges: Extend 36 inches (914 mm) on each side without obstructing continuous ridge vent slot.

3.3 METAL FLASHING INSTALLATION

A. General: Install metal flashings and other sheet metal to comply with requirements in Division 07 Section "Sheet Metal Flashing and Trim."

1. Install metal flashings according to recommendations in ARMA's "Residential Asphalt Roofing Manual" and asphalt shingle recommendations in NRCA's "The NRCA Roofing and Waterproofing Manual."

B. Apron Flashings: Extend lower flange over and beyond each side of downslope asphalt shingles and up the vertical surface.

C. Step Flashings: Install with a headlap of 2 inches (50 mm) and extend over the underlying asphalt shingle and up the vertical surface. Fasten to roof deck only.

D. Rake Drip Edges: Install rake drip edge flashings over underlayment and fasten to roof deck.

E. Eave Drip Edges: Install eave drip edge flashings below underlayment and fasten to roof sheathing.

F. Pipe Flashings: Form flashing around pipe penetrations and asphalt shingles. Fasten and seal to asphalt shingles as recommended by manufacturer.

3.4 ASPHALT SHINGLE INSTALLATION


B. Install starter strip along lowest roof edge, consisting of an asphalt shingle strip with tabs removed at least 6 ½” inches with self-sealing strip face up at roof edge.

1. Extend asphalt shingles 3/4 inch (19 mm) over fasciae at eaves and rakes.
2. Install starter strip along rake edge.
C. Install first and remaining courses of asphalt shingles stair-stepping diagonally across roof deck with manufacturer's recommended offset pattern at succeeding courses, maintaining uniform exposure.

D. Install first and remaining courses of asphalt shingles stair-stepping diagonally across roof deck with manufacturer's recommended offset pattern at succeeding courses, maintaining uniform exposure.

E. Install asphalt shingles by single-strip column or racking method, maintaining uniform exposure. Install full-length first course followed by cut second course, repeating alternating pattern in succeeding courses.

F. Fasten asphalt shingle strips with roofing nails located according to manufacturer's written instructions.
   1. Where roof slope is less than 4:12, seal asphalt shingles with asphalt roofing cement spots.
   2. When ambient temperature during installation is below 50 deg F (10 deg C), seal asphalt shingles with asphalt roofing cement spots.

G. Ridge Vents: Install continuous ridge vents over asphalt shingles according to manufacturer's written instructions. Fasten with roofing nails of sufficient length to penetrate sheathing.

H. Ridge and Hip Cap Shingles: Maintain same exposure of cap shingles as roofing shingle exposure. Lap cap shingles at ridges to shed water away from direction of prevailing winds. Fasten with roofing nails of sufficient length to penetrate sheathing.
   1. Fasten ridge cap asphalt shingles to cover ridge vent without obstructing airflow.

3.5 ROOFING INSTALLER'S WARRANTY

A. WHEREAS <Insert name> of <Insert address>, herein called the "Roofing Installer," has performed roofing and associated work ("work") on the following project:

   1. Owner: <Insert name of Owner>.
   2. Address: <Insert address>.
   3. Building Name/Type: <Insert information>.
   4. Address: <Insert address>.
   5. Area of Work: <Insert information>.
   6. Acceptance Date: <Insert date>.
   7. Warranty Period: <Insert time>.
   8. Expiration Date: <Insert date>.
B. AND WHEREAS Roofing Installer has contracted (either directly with Owner or indirectly as a subcontractor) to warrant said work against leaks and faulty or defective materials and workmanship for designated Warranty Period,

C. NOW THEREFORE Roofing Installer hereby warrants, subject to terms and conditions herein set forth, that during Warranty Period he will, at his own cost and expense, make or cause to be made such repairs to or replacements of said work as are necessary to correct faulty and defective work and as are necessary to maintain said work in a watertight condition.

D. This Warranty is made subject to the following terms and conditions:

1. Specifically excluded from this Warranty are damages to work and other parts of the building, and to building contents, caused by:
   a. Lightning;
   b. Peak gust wind speed exceeding 85 mph;
   c. Fire;
   d. Failure of roofing system substrate, including cracking, settlement, excessive deflection, deterioration, and decomposition;
   e. Faulty construction of parapet walls, copings, chimneys, skylights, vents, equipment supports, and other edge conditions and penetrations of the work;
   f. Vapor condensation on bottom of roofing; and
   g. Activity on roofing by others, including construction contractors, maintenance personnel, other persons, and animals, whether authorized or unauthorized by Owner.

2. When work has been damaged by any of foregoing causes, Warranty shall be null and void until such damage has been repaired by Roofing Installer and until cost and expense thereof have been paid by Owner or by another responsible party so designated.

3. Roofing Installer is responsible for damage to work covered by this Warranty but is not liable for consequential damages to building or building contents resulting from leaks or faults or defects of work.

4. During Warranty Period, if Owner allows alteration of work by anyone other than Roofing Installer, including cutting, patching, and maintenance in connection with penetrations, attachment of other work, and positioning of anything on roof, this Warranty shall become null and void on date of said alterations, but only to the extent said alterations affect work covered by this Warranty.
If Owner engages Roofing Installer to perform said alterations, Warranty shall not become null and void unless Roofing Installer, before starting said work, shall have notified Owner in writing, showing reasonable cause for claim, that said alterations would likely damage or deteriorate work, thereby reasonably justifying a limitation or termination of this Warranty.

5. During Warranty Period, if original use of roof is changed and it becomes used for, but was not originally specified for, a promenade, work deck, spray-cooled surface, flooded basin, or other use or service more severe than originally specified, this Warranty shall become null and void on date of said change, but only to the extent said change affects work covered by this Warranty.

6. Owner shall promptly notify Roofing Installer of observed, known, or suspected leaks, defects, or deterioration and shall afford reasonable opportunity for Roofing Installer to inspect work and to examine evidence of such leaks, defects, or deterioration.

7. This Warranty is recognized to be the only warranty of Roofing Installer on said work and shall not operate to restrict or cut off Owner from other remedies and resources lawfully available to Owner in cases of roofing failure. Specifically, this Warranty shall not operate to relieve Roofing Installer of responsibility for performance of original work according to requirements of the Contract Documents, regardless of whether Contract was a contract directly with Owner or a subcontract with Owner’s General Contractor.

E. IN WITNESS THEREOF, this instrument has been duly executed this <Insert day> day of <Insert month>, <Insert year>.

1. Authorized Signature: <Insert signature>.
2. Name: <Insert name>.
3. Title: <Insert title>.

END OF SECTION 07311
SECTION 07620
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 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section Includes:
   1. Formed Products:
      a. Formed roof drainage sheet metal fabrications.
      b. Formed steep-slope roof sheet metal fabrications.
      c. Formed wall sheet metal fabrications.
      d. Formed equipment support flashing.

B. Related Sections:
   1. Division 06 Section "Rough Carpentry" for wood nailers, curbs, and blocking.
   2. Division 07 Section "Roof Shingles" for installing sheet metal flashing and trim
      integral with 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. Fabricate and install roof edge flashing capable of resisting the following forces
   according to recommendations in FMG Loss Prevention Data Sheet 1-49:

   1. Wind Zone 1: For velocity pressures of 21 to 30 lbf/sq. ft. (1.00 to 1.44 kPa): 60-
      lbf/sq. ft. (2.87-kPa) perimeter uplift force, 90-lbf/sq. ft. (4.31-kPa) corner uplift
      force, and 30-lbf/sq. ft. (1.44-kPa) outward force.
C. 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 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 edge conditions, including eaves, ridges, valleys, rakes, crickets, and counterflashings as applicable.
6. Details of special conditions.
7. Details of connections to adjoining work.
8. Detail formed flashing and trim at a scale of not less than 3 inches per 12 inches (1:5).

C. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below:

1. Sheet Metal Flashing: 12 inches (300 mm) long by actual width of unit, including finished seam and in required profile. Include fasteners, cleats, clips, closures, and other attachments.
2. Trim, Metal Closures, Expansion Joints, Joint Intersections, and Miscellaneous Fabrications: 12 inches (300 mm) long and in required profile. Include fasteners and other exposed accessories.

D. Qualification Data: For qualified fabricator.
E. Maintenance Data: For sheet metal flashing, trim, and accessories to include in maintenance manuals.

F. Warranty: Sample of special warranty.

1.5 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.

1.6 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.

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.

B. Metallic-Coated Steel Sheet: Restricted flatness steel sheet, metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.

1. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation; structural quality.

2. Surface: Smooth, flat.
2.2 UNDERLAYMENT MATERIALS

A. Self-Adhering, High-Temperature Sheet: Minimum 60 mils thick, consisting of slip-resisting polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.

2. Low-Temperature Flexibility: ASTM D 1970; passes after testing at minus 20 deg F (29 deg C).
3. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Carlisle Coatings & Waterproofing Inc.; CCW WIP 300HT.
   c. Henry Company; Blueskin PE200 HT.
   d. Metal-Fab Manufacturing, LLC; MetShield.
   e. Owens Corning; WeatherLock Metal High Temperature Underlayment.

B. Slip Sheet: Building paper, 3-lb/100 sq. ft. (0.16-kg/sq. m) minimum, rosin sized.

2.3 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. Spikes and Ferrules: Same material as gutter; with spike with ferrule matching internal gutter width.

2. Fasteners for Zinc-Coated (Galvanized) Steel Sheet: Hot-dip galvanized steel according to ASTM A 153/A 153M or ASTM F 2329 or Series 300 stainless steel.

C. Solder:
1. For Zinc-Coated (Galvanized) Steel: ASTM B 32, Grade Sn50, 50 percent tin and 50 percent lead or Grade Sn60, 60 percent tin and 40 percent lead.

D. Elastomeric Sealant: ASTM C 920, elastomeric 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. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.


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

D. 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.
E. 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.

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

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

2.5 ROOF DRAINAGE SHEET METAL FABRICATIONS

A. Hanging Gutters: Fabricate to cross section indicated, complete with end pieces, outlet tubes, and other accessories as required. Fabricate in minimum 96-inch- (2400-mm-) long sections. Furnish flat-stock gutter spacers and gutter brackets fabricated from same metal as gutters, of size recommended by SMACNA but not less than twice the gutter thickness. Fabricate expansion joints, expansion-joint covers, and gutter accessories from same metal as gutters.

1. Gutter Style: as per drawings
2. Expansion Joints: Lap type.
3. Accessories: Wire ball downspout strainer.
4. Fabricate from the following materials:
   a. Galvanized Steel: 0.022 inch thick.

B. Downspouts: Fabricate round downspouts complete with mitered elbows.

1. Wall attachment: as per drawings
2. Fabricate from the following materials:
   a. Galvanized Steel: 4” schedule 40 pipe
3.

2.6 ROOF SHEET METAL FABRICATIONS

A. Drip Edges: Fabricate from the following materials:

1. Galvanized Steel: 0.022 inch (0.56 mm) thick.

B. Eave, Rake Flashing: Fabricate from the following materials:

1. Galvanized Steel: 0.022 inch (0.56 mm) thick.
C. Counterflashing: Fabricate from the following materials:

1. Galvanized Steel: 0.022 inch (0.56 mm) thick.

D. Roof-Penetration Flashing: Fabricate from the following materials:

1. Galvanized Steel: 0.028 inch (0.71 mm) thick.

2.7 MISCELLANEOUS SHEET METAL FABRICATIONS

A. Equipment Support Flashing: Fabricate from the following materials:

1. 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. 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. Torch cutting of sheet metal flashing and trim is not permitted.
6. 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. 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) 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.

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 07 Section "Joint Sealants."

F. Soldered Joints: Clean surfaces to be soldered, removing oils and foreign matter. Pre-tin edges of sheets to be soldered to a width of 1-1/2 inches (38 mm), except reduce pre-tinning where pre-tinned surface would show in completed Work.

1. Do not solder metallic-coated steel sheet.
2. Do not use torches for soldering. Heat surfaces to receive solder and flow solder into joint. Fill joint completely. Completely remove flux and spatter from exposed surfaces.

G. Rivets: Rivet joints in zinc 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 and 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 eave or apron flashing.
4. Install gutter with expansion joints at locations indicated, but not exceeding, 50 feet (15.24 m) apart. Install expansion-joint caps.

3.5 ROOF FLASHING INSTALLATION

A. General: Install sheet metal flashing and trim to comply with performance requirements and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, set units true to line, and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
B. Roof Edge Flashing: Anchor to resist uplift and outward forces according to recommendations in SMACNA's "Architectural Sheet Metal Manual" and as indicated. Interlock bottom edge of roof edge flashing with continuous cleat anchored to substrate at staggered 3-inch (75-mm) centers.

C. Roof Edge Flashing: Anchor to resist uplift and outward forces according to recommendations in FMG Loss Prevention Data Sheet 1-49 for specified wind zone and as indicated. Interlock bottom edge of roof edge flashing with continuous cleat anchored to substrate at 16-inch (400-mm) centers.

D. Roof-Penetration Flashing: Coordinate installation of roof-penetration flashing with installation of roofing and other items penetrating roof. Seal with elastomeric sealant and clamp flashing to pipes that penetrate roof.

3.6 MISCELLANEOUS FLASHING INSTALLATION

A. 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.

3.7 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."

3.8 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 07620
PART 1 - GENERAL

1.01 SUMMARY

A. Scope
   1. This Section specifies roof hatches
   2. Contractor shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install all roof hatch Work.
   3. Extent of roof hatches is shown on the Plans.
   4. Types of products required include the following
      a. Pump access roof hatch.
      b. Miscellaneous hardware, closures, fasteners and other accessories.

B. Coordination
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with the roof hatch Work.

C. Scheduling
   1. Coordinate the installation of roof hatch Work with roofing and flashing Work in order to provide continuity in the installation of roofing Work and to obtain complete and permanently weather-resistant and waterproof construction.
   2. Schedule roof hatch items to arrive at the Site as installation of the roofing Work is proceeding such that roof accessory items can be built into the Work as shown on approved Shop Drawings and without the need for field changes to approved installation details or methods of flashing.

D. Protection
   1. Provide continuous protection of materials against damage primarily by storing materials under cover and above ground and away from other construction traffic.

1.02 QUALITY ASSURANCE

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

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWPA</td>
<td>LP-2, Softwood Lumber, Timber and Plywood Pressure Treatment with Water-Borne Preservatives of Above Ground Use</td>
</tr>
<tr>
<td>ASTM A 1011</td>
<td>Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability</td>
</tr>
<tr>
<td>ASTM B 221</td>
<td>Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles and Tubes</td>
</tr>
<tr>
<td>NAAMM</td>
<td>Metal Finishes Manual</td>
</tr>
<tr>
<td>SMACNA</td>
<td>Architectural Sheet Metal Manual</td>
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</table>

B. Warranty

1. A warranty for the equipment specified under this Section shall be provided in accordance with the General Conditions. The Warranty shall be for one (1) year from the date of the Notice of Substantial Completion certificate issued for the Work. If extended warranties are required, a special paragraph calling for an extended warranty will be included in this Section.

2. Pump Access Roof Hatches: Contractor shall furnish a written guarantee obtained from the Supplier of the roof hatches. Guarantee shall state the following:

   a. Roof hatch is to operate properly and be free of defects in material and workmanship for a period of five years from date of Final Completion.
Roof Hatches
07721-3

b. Should any part fail to function, or break in normal use during this period, Supplier shall furnish and install a new part, at no additional cost to the Owner.

C. Fabrication Criteria
   1. Pump Access Roof Hatch
      a. Fabricate access roof hatches to withstand a live load of 40 pounds per square foot over the horizontal plane of the hatch and a concurrently acting point load of 200 pounds located at the center of the hatches. Specified loadings shall not cause any permanent deflections in the hatch or support curbs or cause damage to operating hardware.

D. Requirements of Regulatory Agencies
   2. OSHA, Section 1910.27.

E. Component Supply and Compatibility: Obtain materials only from Suppliers that will, if required
   1. Send a qualified technical representative to the Site, for the purpose of advising the installer of proper procedures and precautions during the installation of the items.
   2. Engage Suppliers who have been successfully providing roof accessories of the type specified and who will submit a list of successful installations.

1.03 SUBMITTALS

A. Preconstruction/Action Submittals: The following minimum submittals shall be submitted prior to construction of this element of the Work in accordance with Section 01330 - Submittals.

   1. A copy of this Section, with addendum updates included, and all referenced and applicable Sections, with addendum updates included, with each paragraph check-marked to indicate Specification compliance or marked to indicate requested deviations from Specification requirements or those parts which are to be provided by the Contractor or others shall be provided. Check marks (✓) shall denote full compliance with a paragraph as a whole.

   If deviations from the Specifications are indicated, and therefore requested, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations.
Roof Hatches
07721-4

The remaining portions of the paragraph not underlined shall signify compliance with the Specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the requirements of the Specification shall be cause for rejection of the entire submittal and no further submittal material will be reviewed.

2. Shop Drawings
   a. Copies of Suppliers proposed fabrication details and material Specifications for each roof accessory item. Include flashing and roughing-in drawings showing this Work coordinated with the roofing Work as appropriate to the location of the item.
   b. Provide Supplier’s Specifications, installation and coordination instructions and other data as may be requested by Engineer substantiating that products comply with the requirements.
   c. Maintenance Manuals: Upon completion of the Work, furnish six copies of detailed maintenance manuals including the following information
      1) Product name and number.
      2) Name, address and telephone number of Supplier’s local distributor.
      3) Detailed procedures for routine maintenance and cleaning, including cleaning materials, application methods and precautions as to use of materials that may be detrimental to finish when improperly applied.

PART 2 - PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Supplier Qualifications
   1. The Supplier shall have 5 years of experience manufacturing and installing roof hatches in similar-sized projects.
      a. Provide Supplier’s standard units, modified as necessary to comply with the requirements of these Specifications. Custom fabricate units wherever necessary for size, type and profile, using Supplier’s standard detailing to the extent applicable.
      b. Shop fabricate each unit complete with framing, gaskets, structure, curbs, flashing, well liner, hardware, accessories, anchorage provisions and other components. Disassemble only to the extent required for delivery and installation.

2. Materials
   a. Aluminum: Sheet specified by the Supplier for strength, durability and proper application of finish.
      1) Cover and Curb: 11 gauge, Aluminum.
      2) Cover Liner: 22 gauge, Aluminum.
3) Finish: Mill finish.

b. Insulation: One-inch glass fiber, between panels.

c. Gaskets: Fingered design; polyvinylchloride.

d. Equip units with standard self lifting mechanism accessible from the floor. Provide stainless steel hardware including hold open devices, hinges, compression spring operators enclosed in telescopic tubes, latch, and operating handles for inside operation.

e. Construct units for live loading specified, using Supplier’s standard gauges of metal and fabrication details.

f. Products and Suppliers
   1) Type D–50 Double Leaf Hatch by Bilco Company.
   2) Or Approved Equal.

PART 3 - EXECUTION

3.01 SHIPMENT AND STORAGE

A. Product shall be shipped and stored in accordance with Sections 01651 and 01661.

B. Supplier shall provide Contractor with detailed recommendations and instructions for product storage.

C. Delivery of Materials
   1. Delivery all materials without damage and in Supplier’s original undamaged protective wrappings bearing name and model numbers of approved items.

D. Storage of Materials
   1. Minimize the amount of time roof accessories are stored on Site. If roof hatches do arrive on Site before they can be incorporated into the orderly assembly of the roofing Work store in completely protected and secure enclosures, under cover and away from all construction traffic.
   2. Do not store in contact with earth, wood or concrete or other surfaces which could cause staining or other types of surface marks or blemishes of any kind.

E. Handling of Materials
   1. Do not subject roof hatches to bending or stress of any kind.
   2. Handle and protect units during installation in a manner recommended by the roof hatch Supplier.
3.02 INSPECTION

A. Examine the substrates to receive roof hatches and the conditions under which the roof hatch 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 roof hatch. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to Engineer.

3.03 INSTALLATION

A. The Supplier shall provide the Contractor with detailed recommendations and instructions for installation of the product specified in this Section.

B. Supplier shall provide assistance during product installation as required by the Contractor.

C. Products shall be installed at the locations shown and in accordance with the recommendations of the Supplier.

D. Protection of Aluminum from Dissimilar Materials: Separate metal surfaces of roof hatch from dissimilar metals, and from wood and cementitious substrates. Coat all aluminum surfaces in contact with dissimilar materials such as concrete, masonry, steel and other metals as specified in Section 09900 – Painting and Protective Coatings.

E. Bed flanges of set on accessories in mastic or compound which is compatible with roofing and flashing. On sloping decks, flash flanges with other work for proper water shed.

F. Anchor roof hatch work permanently to the substrate, by approved methods which are adequate for the sizes and locations of units and which will develop load-resistance specified.

3.04 CLEANING AND PROTECTION

A. Clean surfaces of roof hatches as required preventing deterioration and uneven weathering.

Protect roof hatch work from damage until Final Completion.

END OF SECTION 07721
SECTION 07841
PENETRATION FIRESTOPPING

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 through-penetration firestop systems for penetrations through fire-resistance-rated constructions, including both empty openings and openings containing penetrating items.

B. Related Sections include the following:

1. Division 07 Section "Fire-Resistive Joint Systems."
2. Division 21 Sections specifying fire-suppression piping penetrations.
3. Division 22 and 23 Sections specifying duct and piping penetrations.
4. Division 26, 27, and 28 Sections specifying cable and conduit penetrations.

1.3 PERFORMANCE REQUIREMENTS

A. General: For penetrations through the following fire-resistance-rated constructions, including both empty openings and openings containing penetrating items, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

1. Fire-resistance-rated walls including fire walls.

B. Rated Systems: Provide through-penetration firestop systems with the following ratings determined per ASTM E 814 or UL 1479:

1. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, but not less than that equal to or exceeding fire-resistance rating of constructions penetrated.
2. T-Rated Systems: For the following conditions, provide through-penetration firestop systems with T-ratings indicated, as well as F-ratings, where systems protect penetrating items exposed to potential contact with adjacent materials in occupiable floor areas:
   a. Penetrations located outside wall cavities.
   b. Penetrations located outside fire-resistance-rated shaft enclosures.

C. For through-penetration firestop systems exposed to view, traffic, moisture, and physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.
   1. For piping penetrations for plumbing and wet-pipe sprinkler systems, provide moisture-resistant through-penetration firestop systems.
   2. For floor penetrations with annular spaces exceeding 4 inches (100 mm) in width and
   3. For penetrations involving insulated piping, provide through-penetration firestop systems not requiring removal of insulation.

D. For through-penetration firestop systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

1.4 SUBMITTALS

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

B. Shop Drawings: For each through-penetration firestop system, show each type of construction condition penetrated, relationships to adjoining construction, and type of penetrating item. Include firestop design designation of qualified testing and inspecting agency that evidences compliance with requirements for each condition indicated.
   1. Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each through-penetration firestop system configuration for construction and penetrating items.
   2. Where Project conditions require modification to a qualified testing and inspecting agency's illustration for a particular through-penetration firestop condition, submit illustration, with modifications marked, approved by through-penetration firestop system manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.
C. Qualification Data: For Installer.

D. Product Certificates: For through-penetration firestop system products, signed by product manufacturer.

E. Product Test Reports: From a qualified testing agency indicating through-penetration firestop system complies with requirements, based on comprehensive testing of current products.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A firm that has been approved by FMG according to FMG 4991, "Approval of Firestop Contractors."

B. Installation Responsibility: Assign installation of through-penetration firestop systems in Project to a single qualified installer.

C. Source Limitations: Obtain through-penetration firestop systems, for each kind of penetration and construction condition indicated, through one source from a single manufacturer.

D. Fire-Test-Response Characteristics: Provide through-penetration firestop systems that comply with the following requirements and those specified in Part 1 "Performance Requirements" Article:

1. Firestopping tests are performed by a qualified testing and inspecting agency. A qualified testing and inspecting agency is UL, OPL ITS, or another agency performing testing and follow-up inspection services for firestop systems acceptable to authorities having jurisdiction.

2. Through-penetration firestop systems are identical to those tested per testing standard referenced in "Part 1 Performance Requirements" Article. Provide rated systems complying with the following requirements:

   a. Through-penetration firestop systems correspond to those indicated by reference to through-penetration firestop system designations listed by the following:

      1) UL in its "Fire Resistance Directory."
      2) OPL in its "Directory of Listed Building Products, Materials, & Assemblies."
      3) ITS in its "Directory of Listed Products."

E. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."
1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver through-penetration firestop system products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacture, lot number, shelf life if applicable, qualified testing and inspecting agency's classification marking applicable to Project, curing time, and mixing instructions for multicomponent materials.

B. Store and handle materials for through-penetration firestop systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not install through-penetration firestop systems when ambient or substrate temperatures are outside limits permitted by through-penetration firestop system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Ventilate through-penetration firestop systems per manufacturer's written instructions by natural means or, where this is inadequate, forced-air circulation.

1.8 COORDINATION

A. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.

B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.

C. Notify Owner's inspecting agency at least seven days in advance of through-penetration firestop system installations; confirm dates and times on days preceding each series of installations.

D. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until each installation has been examined by building inspector, if required by authorities having jurisdiction.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Products: Subject to compliance with requirements, through-penetration firestop systems that may be incorporated into the Work include, but are not limited to, those systems indicated in the Through-Penetration Firestop System Schedule at the end of Part 3 are produced by one of the following manufacturers:

3. Hilti, Inc.
6. NUCO Inc.
7. RectorSeal Corporation (The).
8. Specified Technologies Inc.
9. 3M; Fire Protection Products Division.
10. Tremco; Sealant/Weatherproofing Division.
11. USG Corporation.

2.2 FIRESTOPPING, GENERAL

A. Compatibility: Provide through-penetration firestop systems that are compatible with one another; with the substrates forming openings; and with the items, if any, penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by through-penetration firestop system manufacturer based on testing and field experience.

B. Accessories: Provide components for each through-penetration firestop system that are needed to install fill materials and to comply with Part 1 "Performance Requirements" Article. Use only components specified by through-penetration firestop system manufacturer and approved by qualified testing and inspecting agency for firestop systems indicated. Accessories include, but are not limited to, the following items:

1. Permanent forming/damming/backing materials, including the following:
   a. Slag-/rock-wool-fiber insulation.
   b. Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.
   c. Fire-rated form board.
d. Fillers for sealants.

2. Temporary forming materials.
5. Steel sleeves.

2.3 FILL MATERIALS

A. General: Provide through-penetration firestop systems containing the types of fill materials indicated in the Through-Penetration Firestop System Schedule at the end of Part 3 by referencing the types of materials described in this Article. Fill materials are those referred to in directories of referenced testing and inspecting agencies as "fill," "void," or "cavity" materials.

B. Cast-in-Place Firestop Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer metallic sleeve lined with an intumescent strip, a radial extended flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.

C. Latex Sealants: Single-component latex formulations that after cure do not re-emulsify during exposure to moisture.

D. Firestop Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.

E. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced elastomeric sheet bonded to galvanized steel sheet.

F. Intumescent Putties: Nonhardening dielectric, water-resistant putties containing no solvents, inorganic fibers, or silicone compounds.

G. Intumescent Wrap Strips: Single-component intumescent elastomeric sheets with aluminum foil on one side.

H. Mortars: Prepackaged dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers, and lightweight aggregate formulated for mixing with water at Project site to form a nonshrinking, homogeneous mortar.

I. Pillows/Bags: Reusable heat-expanding pillows/bags consisting of glass-fiber cloth cases filled with a combination of mineral-fiber, water-insoluble expansion agents, and fire-retardant additives.

J. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.
K. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below:

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces, and nonsag formulation for openings in vertical and other surfaces requiring a nonslumping, gunnable sealant, unless indicated firestop system limits use to nonsag grade for both opening conditions.
2. Grade for Horizontal Surfaces: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces.

2.4 MIXING

A. For those products requiring mixing before application, comply with through-penetration firestop system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of work.

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

3.2 PREPARATION

A. Surface Cleaning: Clean out openings immediately before installing through-penetration firestop systems to comply with firestop system manufacturer's written instructions and with the following requirements:

1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of through-penetration firestop systems.
2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with through-penetration firestop systems. Remove loose particles remaining from cleaning operation.

3. Remove laitance and form-release agents from concrete.

B. Priming: Prime substrates where recommended in writing by through-penetration firestop system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

C. Masking Tape: Use masking tape to prevent through-penetration firestop systems from contacting adjoining surfaces that will remain exposed on completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from firestop system materials. Remove tape as soon as possible without disturbing firestop system's seal with substrates.

3.3 THROUGH-PENETRATION FIRESTOP SYSTEM INSTALLATION

A. General: Install through-penetration firestop systems to comply with Part 1 "Performance Requirements" Article and with firestop system manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Install forming/damming/backing materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.

1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.

C. Install fill materials for firestop systems by proven techniques to produce the following results:

1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.
2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
3. For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.
3.4 IDENTIFICATION

A. Identify through-penetration firestop systems with preprinted metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6 inches (150 mm) of edge of the firestop systems so that labels will be visible to anyone seeking to remove penetrating items or firestop systems. Use mechanical fasteners for metal labels. For plastic labels, use self-adhering type with adhesives capable of permanently bonding labels to surfaces on which labels are placed and, in combination with label material, will result in partial destruction of label if removal is attempted. Include the following information on labels:

1. The words "Warning - Through-Penetration Firestop System - Do Not Disturb. Notify Building Management of Any Damage."
2. Contractor's name, address, and phone number.
3. Through-penetration firestop system designation of applicable testing and inspecting agency.
4. Date of installation.
5. Through-penetration firestop system manufacturer's name.
6. Installer's name.

3.5 FIELD QUALITY CONTROL

A. Inspecting Agency: Owner will engage a qualified, independent inspecting agency to inspect through-penetration firestops. Independent inspecting agency shall comply with ASTM E 2174 requirements including those related to qualifications, conducting inspections, and preparing test reports.

B. Where deficiencies are found, repair or replace through-penetration firestop systems so they comply with requirements.

C. Proceed with enclosing through-penetration firestop systems with other construction only after inspection reports are issued and firestop installations comply with requirements.

3.6 CLEANING AND PROTECTING

A. Clean off excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not damage materials in which openings occur.
B. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce systems complying with specified requirements.

3.7 THROUGH-PENETRATION FIRESTOP SYSTEM SCHEDULE

A. Where UL-classified systems are indicated, they refer to alpha-alpha-numeric designations listed in UL's "Fire Resistance Directory" under product Category XHEZ.

B. Where OPL-classified systems are indicated, they refer to alpha-numeric design numbers in OPL's "Directory of Listed Building Products, Materials, & Assemblies."

C. Where ITS-listed systems are indicated, they refer to design numbers listed in ITS's "Directory of Listed Products," "Firestop Systems" Section.

D. Firestop Systems for Metallic Pipes, Conduit, or Tubing:
   2. Type of Fill Materials: One or more of the following:
      a. Latex sealant.
      b. Silicone sealant.
      c. Intumescent putty.
      d. Mortar.

E. Firestop Systems for Nonmetallic Pipe, Conduit, or Tubing:
   2. Type of Fill Materials: One or more of the following:
      a. Latex sealant.
      b. Silicone sealant.
      c. Intumescent putty.
      d. Intumescent wrap strips.
      e. Firestop device.

F. Firestop Systems for Miscellaneous Mechanical Penetrants:
   2. Type of Fill Materials: One or both of the following:
      a. Latex sealant.
b. Mortar.

G. Firestop Systems for Groupings of Penetrants:

2. Type of Fill Materials: One or more of the following:
   a. Latex sealant.
   b. Mortar.
   c. Intumescent wrap strips.
   d. Firestop device.
   e. Intumescent composite sheet.
PART 1 - GENERAL

1.01 DESCRIPTION

1.02 SUBMITTALS

1.03 WARRANTY

PART 2 - PRODUCTS

2.01 MATERIALS

PART 3 - EXECUTION

3.01 GENERAL

3.02 PREPARATION

3.03 APPLICATION

3.04 CLEAN-UP AND PROTECTION

3.05 QUALITY CONTROL
PART 1 - GENERAL

1.01 DESCRIPTION
Requirements specified in Conditions of the Contract and Division 1 form a part of this Section. Provide all sealant and caulking work, complete as indicated, specified and required.

A. Work Included in This Section. Principal items are:

1. This Specification is intended to be general in scope as to locations of caulking and sealants. Contractor shall examine all Drawings and Details thoroughly and familiarize himself with the extent of the caulking and sealing involved. Only a complete and absolutely watertight and weathertight job will be accepted.

2. Additional information pertaining to sealing and/or caulking will be found in the various specific trade sections and shall be coordinated with the work of this Section.

B. Related Work Not in This Section. Concrete Work, Masonry Work, Doors and Frames, Painting, Gypsum Drywall, Weatherstripping and Sound Sealing integral to manufactured items, and caulking required for piping, conduit or other mechanical or electrical work.

1.02 SUBMITTALS
Prior to purchase or delivery of materials, submit the following, and obtain District acceptance.

A. Samples and Technical Data

1. Submit technical data by all manufacturers of proposed materials.

2. Submit material manufacturers' printed preparation and application instructions to District and furnish copies to all trades concerned.

B. Shop Drawings and Mock-Ups. When requested, submit the following in accordance with these specifications:

1. Full-size details indicating all the necessary components for each type of joint to be sealed.
2. Observed field conditions and measurements. Mock-up units or test sections shall be also scheduled after receiving written approval of shop drawings by the District.

1.03 WARRANTY
Contractor shall fully guarantee all materials and workmanship under this Section for a period of three (3) years from the date of final acceptance of the structure against all defects in both workmanship and materials and he shall promptly correct and/or replace such faulty work if so notified, at no additional cost to the District.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Delivery. Deliver sealant and caulking compounds in unopened factory labeled containers; labels bearing statement of conformance to standards specified for each material; and bearing manufacturer's name and product designation.

B. Colors. As selected to match adjoining surfaces. Special colors may be required.

C. Sealant Compounds. Materials shall conform to Fed. Spec. TT-S-00227E(3) for multi-component sealant, or to Fed. Spec. TT-S-00230C(2) for single component sealant. Properties and adhesion of 1-part sealants shall be equal to 2-part materials. Sealants shall be Type I or Type II, as applicable. Sealants shall be limited to acceptable compounds compositions which are polysulfide, polyurethane, and silicone. For metal buildings, use Class "A" sealants, and for other locations, use Class "B" sealants each conforming with above referenced Federal Specifications or with ASTM C-920 like characteristics. Above grade sealants shall be resistant to ultra violet deteriorations.

1. For joints in water-bearing surfaces, use only polyurethane sealants certified and approved by manufacturer for continuous or intermittent submergence in water or sewage.

2. Silicone type sealant shall be used only on above grade joints which are not subject to vehicular or pedestrian traffic.


D. **Primer**, where required, shall be used as recommended in writing by the sealant manufacturer. Primer shall have been tested for non-staining characteristics and durability on samples of actual surfaces to be sealed.

E. **Back-up Materials and Preformed Joint Fillers.** Use non-staining material, compatible with sealant and primer, and of a resilient nature, such as closed cell polyethylene rod, or elastomeric tubing or rod (neoprene, butyl, or EDPM). Materials impregnated with oil, bitumen, or similar shall not be used. Size and shape shall be as indicated by joint details in Drawings and shall be as recommended by sealant manufacturer in writing. Sealant shall not adhere to back-up material.

F. **Bond Breakers**, where required, shall be polyethylene tape, aluminum foil or other material as recommended by sealant manufacturer in writing.

**PART 3 - EXECUTION**

3.01 **GENERAL**

A. Perform work of this Section by material manufacturer’s approved applicator in strict conformance with manufacturer’s printed instructions, or perform such operations under direct supervision of qualified representative of material manufacturer.

B. Applicator shall examine all surfaces and report to the General Contractor all conditions not acceptable.

3.02 **PREPARATION**

A. Thoroughly clean all joints, removing all foreign matter such as dust, oil, grease, water, surface dirt, frost and old caulking materials. Sealant must be applied to the base surface. Previously applied paint or primer must be entirely removed.

B. Porous materials such as concrete masonry or stone should be cleaned where necessary by grinding, blast-cleaning, mechanical abrading, acid washing or combination of these methods to provide a clean, sound base surface for sealant adhesion.

1. Laitance shall be removed by acid washing, grinding, or mechanical abrading.

2. Form oils shall be removed by blast-cleaning.
3. Loose particles present or resulting from grinding, abrading or blast-cleaning shall be removed by blowing out joints with oil-free compressed air (or vacuuming) prior to application of primer or sealant.

C. Non-porous surfaces, such as metal and glass, shall be cleaned either mechanically or chemically. Protective coatings such as methacrylate lacquer on metallic surfaces shall be removed by a solvent that leaves no residue. Solvent shall be used with clean cloths or lintless paper towels. Do not allow solvent to air dry without wiping. Wipe dry with clean, dry cloth, or lintless paper towels.

D. Joint areas to be protected with masking tape or strippable films shall be cleaned before application of tape or film.

E. All joints to receive sealant shall be as indicated on shop or Project Drawings. Do not seal joints until they are in compliance with drawings or are acceptable to the Engineer.

   1. Joints to receive sealant shall be a minimum of 1/4 inch wide by 1/4 inch deep, unless otherwise approved.

   2. For joints in concrete, masonry, or stone: depth of the sealant may be equal to the width of joints up to 1/2 inch wide. For joints 1/2 inch to 1 inch wide: depth shall be 1/2 inch. For expansion and other joints, 1 to 2 inches wide: depth shall be no greater than 1/2 the applied sealant width. For joints exceeding 2 inches (5 cm) in width: depth shall be as directed by sealant manufacturer.

   3. For joints in metal, glass, and other non-porous surfaces: sealant depth shall be a minimum of 1/2 the applied sealant width, and shall in no case exceed the applied sealant width.

F. Joints to receive sealant, back-up material or pre-formed joint filler shall be cleaned out, raked to full width and depth as required by Applicator.

G. Joints shall be of sufficient width and depth to accommodate specified back-up material or pre-formed joint filler and sealant.

3.03 APPLICATION

A. Install back-up material or joint filler, of type and size specified, at proper depth to provide sealant dimensions as detailed. Back-up material shall be of suitable size and shape; and compressed 25-50 percent to fit joints as required. Sealant shall not be applied without back-up material and/or bond breaker strip. When using back-up tubes avoid lengthwise stretching. Tube or rod shall not be twisted or braided.

B. Apply masking tape, where required, in continuous strips in alignment with joint edge.
C. Prime surfaces, where required, with primer as recommended by sealant manufacturer.

D. Follow sealant manufacturer's instruction regarding mixing (if required), surface preparation, priming, and application procedure.

E. Apply sealant under pressure with hand or power actuated gun or other appropriate means. Gun shall have nozzle of proper size and provide sufficient pressure to completely fill joints as designed. All joint surfaces shall be tooled to provide the contour as indicated on Drawings. When tooling joints, use tooling solution recommended by manufacturer. Remove masking tape immediately after joints have been tooled.

1. For sealant application when air temperature is below forty degrees (40°) Fahrenheit (four degrees (4°) Centigrade), consult sealant manufacturer for recommendations.

3.04 CLEAN-UP AND PROTECTION
Clean adjacent surfaces of sealant as work progresses. Use solvent or cleaning agent as recommended by sealant manufacturer. All finished work shall be left in a neat, clean condition.

3.05 QUALITY CONTROL
The sealant joints shall be uniformly smooth, free of wrinkles, flush with adjacent surfaces and absolutely watertight. Adjacent surfaces which have been soiled by the application of the sealing compound shall be wiped clean and be left neat. The work will be judged defective due to the sealant's hardening, cracking, crumbling, melting, shrinking, leaking, or running.

END OF SECTION 07920
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. Standard hollow metal doors and frames.

B. Related Sections:

1. Division 04 Section "Unit Masonry" for embedding anchors for hollow metal work into masonry construction.
2. Division 08 Section "Door Hardware" for door hardware for hollow metal doors.
3. Division 09 Sections "Exterior 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 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 conduit and preparations for power, signal, and control systems.

C. 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.

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

E. 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.

1.5 QUALITY ASSURANCE

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

B. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure according to NFPA 252, 2007 California Referenced Standard 12-7-4 or UL 10B UL 10C.

1.6 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 non-vented 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.

1.7 PROJECT CONDITIONS

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

1.8 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.
7. Fleming Door Products Ltd.; an Assa Abloy Group company.
10. Kewanee Corporation (The).
11. Mesker Door Inc.
14. Steelcraft; an Ingersoll-Rand company.
15. Windsor Republic Doors.
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. 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.

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

E. 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.

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

G. 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 ratings indicated.
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.

B. Exterior Doors: Face sheets fabricated from metallic-coated steel sheet. 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. Width: 1-3/4 inches (44.5 mm).
2. Level 3 and Physical Performance Level A (Extra Heavy Duty), Model 1 (Full Flush).

C. Interior Doors: Face sheets fabricated from cold-rolled steel sheet. 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. Width: 1-3/4 inches (44.5 mm).
2. Level 3 and Physical Performance Level A (Extra Heavy Duty), Model 1 (Full Flush).

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

E. 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.


1. Fabricate frames with mitered or coped corners.
2. Fabricate frames as full profile welded unless otherwise indicated.
3. Frames for Level 3 Steel Doors: 0.053-inch- (1.3-mm-) thick steel sheet.

C. Interior Frames: Fabricated from cold-rolled steel sheet.

1. Fabricate frames with mitered or coped corners.
2. Fabricate frames as full profile welded unless otherwise indicated.
3. Frames for Level 3 Steel Doors: 0.053-inch- (1.3-mm-) thick steel sheet.

D. 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. 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.

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

2.8 ACCESSORIES

A. 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 SDI 117 and 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. 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. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
3. Grout Guards: Weld guards to frame at back of hardware mortises in frames to be grouted.
4. Floor Anchors: Weld anchors to bottom of jambs and mullions with at least four spot welds per anchor.
5. 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) Three anchors per jamb from 60 to 90 inches (1524 to 2286 mm) high.
      2) Four anchors per jamb from 90 to 120 inches (2286 to 3048 mm) high.
   b. 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.
6. 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 08 Section "Door Hardware."
   1. Locate hardware as indicated, or if not indicated, according to ANSI/SDIA250.8 and 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/SDIA250.6 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 26 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. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames.
   2. Provide loose stops and moldings on inside of hollow metal work.
   3. Coordinate rabbet width between fixed and removable stops with type of glazing and type of installation indicated.

2.10 STEEL 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/SDIA250.10 acceptance criteria; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.
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 door silencers in frames before grouting.
   d. Remove temporary braces necessary for installation only after frames have been properly set and secured.
   e. Check plumbness, squareness, and twist of frames as walls are constructed. Shim as necessary to comply with installation tolerances.
   f. 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 Bottom of Door and Top of Threshold: Maximum 3/8 inch (9.5 mm).

2. Fire-Rated Doors: Install doors with clearances according to NFPA 80.

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.
SECTION 08331
OVERHEAD COILING DOORS

PART 1 - GENERAL

1.01 SUMMARY

A. Scope
   1. This Section specifies overhead coiling service doors.

B. Performance Requirements
   1. Structural Performance, Exterior Doors Capable of withstanding the design wind loads.
      a. Design Wind Load As indicated on Drawings.
      b. Deflection Limits Design overhead coiling doors to withstand design wind load without evidencing permanent deformation or disengagement of door components.
      c. Operability under Wind Load Design overhead coiling doors to remain operable under design wind load, acting inward and outward.
   2. Seismic Performance Overhead coiling doors shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
      a. Component Importance Factor 1.5.
   3. Environmental Conditions Door components and assembly to be constructed and warranted for salt spray exposure.

1.02 QUALITY ASSURANCE

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

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<th>Reference</th>
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<tr>
<td>CBC</td>
<td>California Building Code</td>
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<tr>
<td>National Fire Protection Association (NFPA)</td>
<td>Specification for Carbon Structural Steel</td>
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<tr>
<td>Underwriters Laboratories Inc, (UL)</td>
<td>Building Materials Directory</td>
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B. Warranty A warranty for the products and materials specified under this Section shall be provided. The Warranty shall be for two (2) years from the date of the Notice of Substantial Completion certificate issued for the Work.

C. Installer Qualifications An entity that employs installers and supervisors who are trained and approved by Supplier for both installation and maintenance of units required for this Work.

1.03 SUBMITTALS

A. Preconstruction/Action Submittals The following minimum submittals shall be submitted prior to construction of this element of the Work in accordance with Section 01330 - Submittal Procedures.

1. A copy of this Section, with addendum updates included, and all referenced and applicable Sections, with addendum updates included, with each paragraph check-marked to indicate Specification compliance or marked to indicate requested deviations from Specification requirements or those parts which are to be provided by the Contractor or others shall be provided. Check marks (✓) shall denote full compliance with a paragraph as a whole.

If deviations from the Specifications are indicated, and therefore requested, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Owner Representative shall be the final authority for determining acceptability of requested deviations.

The remaining portions of the paragraph not underlined shall signify compliance with the Specifications.
Failure to include a copy of the marked-up Specification Sections, along with justification(s) for any requested deviations to the requirements of the Specification shall be cause for rejection of the entire submittal and no further submittal material will be reviewed.

2. Product Data For each type and size of overhead coiling door and accessory.
   a. Include construction details, material descriptions, dimensions of individual components, profiles for slats, and finishes.
   b. Include rated capacities, operating characteristics, electrical characteristics, and furnished accessories.

3. Shop Drawings For each installation and for special components not dimensioned or detailed in Supplier's product data.
   a. Include plans, elevations, Sections, and mounting details.
   b. Include details of equipment assemblies, and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
   c. Include points of attachment and their corresponding static and dynamic loads imposed on structure.
   d. For exterior components, include details of provisions for assembly expansion and contraction and for excluding and draining moisture to the exterior.
   e. Include diagrams for power, signal, and control wiring.

4. Samples for Verification For each type of exposed finish on the following components, in Supplier's standard sizes
   a. Curtain slats.
   b. Include similar Samples of accessories involving color selection.

5. Qualification Data
   a. Installer.
   b. Factory-authorized service representative.
   c. Supplier.

6. Warranty Information Prior to starting Work, submit sample copy of warranty to be provided.

B. Informational Submittals The following minimum informational submittals shall be submitted in accordance with the timing requirements specified in these Contract Documents, prior to Substantial Completion and in accordance with Section 01330 - Submittal.

1. Operating and Maintenance Information
2. Installer Certificates Signed by Supplier certifying that installers comply with specified requirements.
3. Warranty Submit Supplier’s warranty showing conformance to provisions of this Section.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Suppliers

B. Source Limitations Obtain overhead coiling doors from single source from single Supplier.
   1. Obtain operators and controls from overhead coiling door Supplier.

C. Supplier Qualifications
   1. The Supplier shall have five (5) years of experience manufacturing and installing overhead coiling doors in similar-sized projects.

2.02 MATERIALS

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose. If alternatives are proposed, the proposals shall be accompanied with documentation supporting the claimed superiority of the proposed substitutions. The Engineer shall be the sole decider in the equivalency of alternative materials of construction.

2.03 DOOR ASSEMBLY

A. Service Door Overhead coiling door formed with curtain of interlocking metal slats.
   1. Suppliers Subject to compliance with requirements, available Suppliers offering products that may be incorporated into the Work include, but are not limited to the following
      b. Or Approved Equal

B. Operation Cycles Door components and operators capable of operating for not less than one hundred thousand (100,000) cycles. One (1) operation cycle is complete when a door is opened from the closed position to the fully open position and returned to the closed position.
   1. Include tamperproof cycle counter.
C. Door Curtain Material Aluminum.

D. Door Curtain Slats Flat profile slats of 3-1/4-inch center-to-center height.
   1. Gasket Seal. Supplier's standard continuous gaskets between slats.

E. Bottom Bar Two (2) angles, each not less than 1-1/2 by 1-1/2 by 1/8 inch thick; fabricated from stainless steel and finished to match door.

F. Curtain Jamb Guides Galvanized steel with exposed finish matching curtain slats.

G. Hood Match curtain material and finish.
   1. Shape Square.
   2. Mounting Face of wall.

H. Locking Devices Equip door with slide bolt for padlock.
   1. Locking Device Assembly Cremone-type, both jamb sides locking bars, operable from inside with thumb turn.

I. Electric Door Operator
   1. Usage Classification Medium duty, up to twelve (12) cycles per hour and up to fifty (50) cycles per day.
   2. Operator Location Top of hood.
   5. Obstruction-Detection Device Automatic photoelectric sensor and electric sensor edge on bottom bar.
      a. Sensor Edge Bulb Color As selected by City Representative from Supplier's full range.
   6. Control Station(s) Interior-mounted.
   7. Other Equipment Audible and visual signals.

J. Curtain Accessories Equip door with weatherseals pull-down strap and automatic closing device.
K. Door Finish
   1. Baked-Enamel or Powder-Coated Finish Color as selected by Engineer from Supplier’s full range color chart.
   2.

2.04 DOOR CURTAIN MATERIALS AND CONSTRUCTION

A. Door Curtains Fabricate overhead coiling-door curtain of interlocking metal slats, designed to withstand wind loading indicated, in a continuous length for width of door without splices. Unless otherwise indicated, provide slats of thickness and mechanical properties recommended by door Supplier for performance, size, and type of door indicated, and as follows
   1. Steel Door Curtain Slats Zinc-coated (galvanized), cold-rolled structural-steel sheet; complying with ASTM A 653, with G90 zinc coating; nominal sheet thickness (coated) of 0.028 inch; and as required.

B. Curtain Jamb Guides Supplier’s standard angles or channels and angles of same material and finish as curtain slats unless otherwise indicated, with sufficient depth and strength to retain curtain, to allow curtain to operate smoothly, and to withstand loading. Slot bolt holes for guide adjustment. Provide removable stops on guides to prevent over-travel of curtain, and a continuous bar for holding windlocks.

2.05 HOODS

A. General Form sheet metal hood to entirely enclose coiled curtain and operating mechanism at opening head. Contour to fit end brackets to which hood is attached. Roll and reinforce top and bottom edges for stiffness. Form closed ends for surface-mounted hoods and fascia for any portion of between-jamb mounting that projects beyond wall face. Equip hood with intermediate support brackets as required to prevent sagging.
   1. Galvanized Steel Nominal 0.028-inch- thick, hot-dip galvanized-steel sheet with G90 zinc coating, complying with ASTM A 653.

2.06 LOCKING DEVICES

A. Slide Bolt Fabricate with side-locking bolts to engage through slots in tracks for locking by padlock, located on both left and right jamb sides, operable from coil side.

B. Safety Interlock Switch Equip power-operated doors with safety interlock switch to disengage power supply when door is locked.
2.07 CURTAIN ACCESSORIES

A. Weatherseals for Exterior Doors Equip each exterior door with weather-stripping gaskets fitted to entire exterior perimeter of door for a weather-resistant installation unless otherwise indicated.
   1. At door head, use 1/8-inch-thick, replaceable, continuous-sheet baffle secured to inside of hood or field-installed on the header.
   2. At door jambs, use replaceable, adjustable, continuous, flexible, 1/8-inch-thick seals of flexible vinyl, rubber, or neoprene.

B. Pull-Down Strap Provide pull-down straps for doors more than 84 inches high.

2.08 COUNTERBALANCING MECHANISM

A. General Counterbalance doors by means of Supplier's standard mechanism with an adjustable-tension, steel helical torsion spring mounted around a steel shaft and contained in a spring barrel connected to top of curtain with barrel rings. Use grease-sealed bearings or self-lubricating graphite bearings for rotating members.

B. Counterbalance Barrel Fabricate spring barrel of Supplier's standard hot-formed, structural-quality, seamless or welded carbon-steel pipe, of sufficient diameter and wall thickness to support rolled-up curtain without distortion of slats and to limit barrel deflection to not more than 0.03 inches/foot of span under full load.

C. Counterbalance Spring One (1) or more oil-tempered, heat-treated steel helical torsion springs. Size springs to counterbalance weight of curtain, with uniform adjustment accessible from outside barrel. Secure ends of springs to barrel and shaft with cast-steel barrel plugs.

D. Torsion Rod for Counterbalance Shaft Fabricate of Supplier’s standard cold-rolled steel, sized to hold fixed spring ends and carry torsional load.

E. Brackets Supplier’s standard mounting brackets of either cast iron or cold-rolled steel plate.

2.09 COATINGS

A. Coatings shall be provided in accordance to Section 09 90 00- Painting and Coating.

B. General Finish Requirements
   1. Comply with NAAMM/NOMMA's "Metal Finishes Manual for Architectural and Metal Products (AMP 500-06)" for recommendations for applying and designating finishes.
   2. Appearance of Finished Work Noticeable variations in same piece are not acceptable.
Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

C. Steel And Galvanized Steel Finishes
   1. Baked-Enamel or Powder-Coat Finish Supplier's standard baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating Supplier's written instructions for cleaning, pretreatment, application, and minimum dry film thickness.

PART 3 EXECUTION

3.01 SHIPMENT AND STORAGE
   A. Equipment shall be shipped and stored in accordance with Sections 01651 and 01661.
   B. Supplier shall provide Contractor with detailed recommendations and instructions for product storage.

3.02 SUPPLIER’S FIELD SERVICES
   A. Supplier shall provide field services.
   B. Supplier shall provide assistance during product installation as required by the Contractor.

3.03 INSTALLATION
   A. The Supplier shall provide the Contractor with detailed recommendations and instructions for installation of the product specified in this Section.
   B. Supplier shall provide assistance during product installation as required by the Contractor.
   C. Products shall be installed at the locations shown and in accordance with the recommendations of the Supplier.
   D. Install overhead coiling doors and operating equipment complete with necessary hardware, anchors, inserts, hangers, and equipment supports; according to Supplier's written instructions and as specified.
   E. Install overhead coiling doors and hoods at the mounting locations indicated for each door.
   F. Examination
1. Examine substrates areas and conditions, with Installer present, for compliance with requirements for substrate construction and other conditions affecting performance of the Work.

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

H. Adjusting
   1. Adjust hardware and moving parts to function smoothly so that doors operate easily, free of warp, twist, or distortion.
      a. Adjust exterior doors and components to be weather-resistant.
   2. Lubricate bearings and sliding parts as recommended by Supplier.

I. Adjust seals to provide tight fit around entire perimeter.

3.04 FIELD TESTING AND COMMISSIONING

   A. Field Testing and Commissioning shall be in accordance with the requirements of Section 01752 – Equipment and System Performance Testing.

   B. The Supplier shall provide detailed procedures for Field Testing and Commissioning procedures for the equipment specified in this Section.

   C. Field Testing and Commissioning shall be performed under the direction of personnel provided by the Supplier.

   D. Following successful Field Testing and Commissioning, Supplier shall provide Certificate of Proper Field Testing and Commissioning.

3.05 TRAINING

   A. Training shall be provided as specified in 01781 – Operations and Maintenance Data.

   B. A minimum of four (4) hours of total training shall be provided.
      1. The four (4) hours of training shall be comprised of the following:
      2. Operations Training: One (1) session, two (2) hours per session.
      3. Maintenance Training: One (1) session, two (2) hours per session.
C. Upon completion of the training activities, the Supplier shall provide a Certification of Training Completion.

END OF SECTION 08331
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 sound-control door assemblies consisting of swinging steel doors, steel frames, sound-control seals, and related accessories to achieve STC ratings indicated.

1. Where scheduled, provide sound-control door assemblies listed and labeled to meet fire ratings indicated.

B. Related Sections include the following:

1. Division 04 Section "Unit Masonry" for building anchors into and grouting sound-control door frames in masonry construction.
2. Division 08 Section "Hollow Metal Doors and Frames" for non-sound-control, hollow-metal doors and frames.
3. Division 08 Section "Door Hardware" for hardware to the extent not specified in this Section, including locksets and cylinders.
4. Division 09 painting Sections for field painting sound-control door assemblies.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

A. Sound Rating: Provide sound-control door assemblies that have been fabricated and tested as sound-retardant units, are identical to assemblies tested according to ASTM E 90 by an independent testing agency, and have the following minimum certified STC rating according to ASTM E 413:

1. STC Rating: 54 single door, 49 double doors.
1.5 SUBMITTALS

A. Product Data: Include sound ratings, construction and hardware preparation details, material and gasketing descriptions, core descriptions, label compliance, dimensions of individual components and profiles, and finishes for sound-control door assemblies.

B. Shop Drawings: In addition to requirements below, provide a schedule of doors and frames using same reference numbers for details and openings as those on Drawings.

1. Elevations of each door design.
2. Details of sound-control seals, door bottoms, and thresholds.
3. Details of doors including vertical and horizontal edge details.
4. Frame details for each frame type including dimensioned profiles.
5. Details and locations of reinforcement and preparations for hardware.
6. Details of each different wall opening condition.
7. Details of anchorages, accessories, joints, and connections.
8. Details of glazing frames and stops showing glazing.

C. Samples for Verification: For each type of exposed finish required, prepared on Samples of not less than 3 by 5 inches (75 by 125 mm).

D. Product Certificates: For each type of sound-control door assembly, signed by product manufacturer.

E. Qualification Data: For Installer.

F. Field quality-control test reports.

G. Product Test Reports: Based on evaluation of comprehensive sound-rating tests performed by a qualified testing agency, for each type of sound-control door assembly.

H. Maintenance Data: For sound-control door assemblies to include in maintenance manuals.

I. Warranty: Special warranty specified in this Section.

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. Acoustical Testing Agency Qualifications: An independent agency accredited as an acoustical laboratory according to the National Voluntary Laboratory Accreditation Program of NIST.
C. Source Limitations: Obtain sound-control door assemblies, including doors, frames, sound-control seals, hinges (when integral for sound control), thresholds, and other items essential for sound control, through one source from a single manufacturer.

D. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination." Review methods and procedures related to sound-control door assemblies including, but not limited to, the following:

1. Review required field quality-control procedures.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver doors and frames palletized, wrapped, or crated to provide protection during transit and Project-site storage. Do not use non-vented plastic.

1. Provide additional protection to prevent damage to finish of factory-finished wood doors.

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

C. Store doors and frames under cover at Project site. Place units in a vertical position with heads up, spaced by blocking, on minimum 4-inch- (100-mm-) high, wood blocking. Avoid using non-vented plastic or canvas shelters that could create a humidity chamber.

1. If wrappers on doors become wet, remove cartons immediately. Provide minimum 1/4-inch (6-mm) space between each stacked door to permit air circulation.

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install sound-control wood doors until spaces are enclosed and weatherproof, wet work in spaces is complete and dry, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

1.9 COORDINATION

A. Coordinate installation of anchorages for sound-control door assemblies.
Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of sound-control door assemblies that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Failure to meet sound rating requirements.
   b. Faulty operation of sound seals.
   c. Deterioration of metals, metal finishes, and other materials beyond normal use or weathering.

2. Warranty Period for Steel Doors: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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. Sound-Control Door Assemblies with Steel Doors:
   a. Ambico Limited.
   b. Amweld Building Products, LLC.
   c. Ceco Door Products; an ASSA ABLOY Group Company.
   d. CURRIES Company; an ASSA ABLOY Group Company.
   e. Firedoor Corporation.
   f. Fleming Door Products Ltd.; an ASSA ABLOY Group Company.
   g. Krieger Steel Products Co.
   h. Overly Door Company.
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 G60 (Z180) zinc (galvanized) or A40 (ZF120) zinc-iron-alloy (galvannealed) coating designation.

D. Supports and Anchors: After fabricating, galvanize units to be built into exterior walls according to ASTM A 153/A 153M, Class B.

E. Inserts, Bolts, and Fasteners: Provide items to be built into exterior walls, 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 sound-control door frames of type indicated.

G. Grout: Comply with Division 04 Section "Unit Masonry."

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-developed indexes of 25 and 50 respectively; passing ASTM E 136 for combustion characteristics.

2.3 STEEL DOORS

A. General: Provide flush-design doors, not less than 1-3/4 inches (44 mm) thick, of seamless hollow construction, unless otherwise indicated. Construct doors with smooth, flush surfaces without visible joints or seams on exposed faces or stile edges.

1. Visible joints or seams around glazed lites are permitted.
2. Bevel both vertical edges 1/8 inch in 2 inches (3 mm in 50 mm).
3. Core: Manufacturer's standard as required to provide STC rating indicated.
B. Exterior Door Face Sheets: Fabricated from minimum 0.042-inch- (1.0-mm-) thick, metallic-coated steel sheet.

C. Interior Door Face Sheets: Fabricated from minimum 0.042-inch- (1.0-mm-) thick, cold-rolled steel sheet, unless otherwise indicated.

D. Top and Bottom Channels: Minimum 0.053-inch- (1.3-mm-) thick, metal channel spot welded, not more than 6 inches (150 mm) o.c., to face sheets.
   1. Tops and bottoms of doors reinforced with inverted horizontal channels, continuous across full width of door, of same material as face sheets so flanges of channels are even with bottom and top edges of face sheets.
   2. Top and bottom edges closed with closing channels of same material and thickness as face sheets; welded so webs of channels are flush with door edges.

E. Hardware Reinforcement: Reinforcement plates fabricated from same material as door face sheets to comply with the following minimum sizes:
   1. Hinges: Minimum 0.167 inch (4.2 mm) thick by 1-1/2 inches (38 mm) wide by 6 inches (150 mm) longer than hinge, secured by not less than 6 spot welds.
   2. Lock Face, Closers, and Concealed Holders: Minimum 0.093 inch (2.3 mm) thick.
   3. All Other Surface-Mounted Hardware: Minimum 0.067 inch (1.7 mm) thick.

F. Miscellaneous Components: Fabricated from hot- or cold-rolled steel sheet.

2.4 STEEL FRAMES

A. General: Fabricate sound-control door frames of full-welded unit construction, with corners mitered, reinforced, and continuously welded full depth and width of frame. Knocked-down frames are not acceptable.
   1. Exterior Frames: Formed from minimum 0.067-inch- (1.7-mm-) thick, metallic-coated steel sheet.
   2. Interior Frames: Formed from minimum 0.067-inch- (1.7-mm-) thick, cold-rolled steel sheet, unless otherwise indicated.

B. Hardware Reinforcement: Fabricate reinforcement plates from same material as door frame to comply with the following minimum sizes:
   1. Hinges: Minimum 0.167 inch (4.2 mm) thick by 1-1/2 inches (38 mm) wide by 6 inches (150 mm) longer than hinge, secured by not less than 6 spot welds.
   2. Strikes and Closers: Minimum 0.093 inch (2.3 mm) thick.
   3. Surface-Mounted Hardware: Minimum 0.093 inch (2.3 mm) thick.
C. Head Reinforcement: Minimum 0.093-inch- (2.3-mm-) thick, steel channel or angle stiffener.

D. Jamb Anchors:
   1. Masonry Type: Adjustable strap-and-stirrup or T-shaped anchors to suit frame size, formed of same material as frame, not less than 0.053 inch (1.3 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 0.156 inch (4.0 mm) wide.

E. Floor Anchors: Formed of same material as door frame, not less than 0.067 inch (1.7 mm) thick, and as follows:
   1. Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners.

F. Ceiling Struts: Minimum 3/8-inch-thick by 2-inch- (9.5-mm-thick by 50-mm-) wide steel.

G. Plaster Guards: Same material as frame, not less than 0.026 inch (0.6 mm) thick.

H. Miscellaneous Components: Fabricated from hot- or cold-rolled steel sheet.

2.5 DOOR HARDWARE

A. General: Provide manufacturer's standard sound-control system, including head and jamb seals, door bottoms, cam-lift hinges, and thresholds, as required by testing to achieve STC rating indicated.

B. Compression Seals: One-piece units; consisting of closed-cell sponge neoprene seal held in place by metal retainer; with retainer cover of same material as door frame; attached to door frame with concealed screws.

C. Magnetic Seals: One-piece units; consisting of closed-cell sponge neoprene seal and resiliently mounted magnet held in place by metal retainer; with retainer cover of same material as door frame; attached to door frame with concealed screws.

D. Automatic Door Bottoms: Neoprene or silicone gasket, held in place by metal housing, that automatically drops to form seal when door is closed; mounted to bottom edge of door with screws.
   1. Mounting: Mortised or semimortised into bottom of door or surface mounted on face of door as required by testing to achieve STC rating indicated.
E. Door Bottoms: Neoprene or silicone gasket held in place by metal housing; mortised into bottom edge of door.

F. Cam-Lift Hinges: Full-mortise template type that raises door 1/2 inch (13 mm) when door is fully open; with hardened pin; fabricated from stainless steel.

G. Thresholds: Flat, smooth, unfluted type as recommended by manufacturer; fabricated from aluminum.
   1. Finish: Color anodic finish.
   2. Color: As selected by Architect from full range of industry colors and color densities.

2.6 FABRICATION

A. General: Fabricate sound-control door assemblies to be rigid and free of defects, warp, or buckle. 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. Steel Doors: Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal. Fabricate doors with faces joined at vertical edges by welding; welds shall be ground, filled, and dressed to make them invisible and to provide a smooth, flush surface.
   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. Comply with clearance requirements in NFPA 80 for fire-rated doors.

C. Steel Frames: Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal. Weld exposed joints continuously; grind, fill, dress, and make smooth, flush, and invisible.
   1. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners, unless otherwise indicated.
   2. Plaster Guards: Weld guards to frame at back of hardware cutouts and glazing-stop screw and sound-control seal preparations to close off interior of openings and prevent mortar or other materials from obstructing hardware operation or installation.
   3. Where installed in masonry, leave vertical mullions in frames open at top for grouting.
4. Floor Anchors: Weld anchors to bottom of jambs and mullions with at least four spot welds per anchor.

5. 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) in height.
      2) Three anchors per jamb from 60 up to 90 inches (1524 up to 2286 mm) in height.
      3) Four anchors per jamb from 90 up to 96 inches (2286 up to 2438 mm) in height.
      4) Four anchors per jamb plus one additional anchor per jamb for each 24 inches (610 mm) or fraction thereof more than 96 inches (2438 mm) in height.

6. Head Reinforcement: For frames more than 48 inches (1219 mm) wide, provide continuous head reinforcement for full width of opening, welded to back of frame at head.

D. Hardware Preparation:

1. Steel Doors and Frames: Factory prepare sound-control doors and frames to receive templated mortised hardware, including providing cutouts, reinforcement, mortising, drilling, and tapping, according to the Door Hardware Schedule and templates furnished as specified in Division 08 Section "Door Hardware."
   a. Reinforce doors and frames to receive non-templated mortised and surface-mounted door hardware.
   b. Comply with HMMA 830, "Hardware Preparation and Locations for Hollow Metal Doors and Frames."
   c. Locate door hardware as indicated, or if not indicated, according to HMMA 831, "Recommended Hardware Locations for Custom Hollow Metal Doors and Frames."

2.7 STEEL FINISHES

A. General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish sound-control steel door assemblies after assembly.
B. Factory Priming for Field-Painted Finish: Apply shop primer specified below immediately after surface preparation and pretreatment. Apply a smooth coat of even consistency to provide a uniform dry film thickness of not less than 0.7 mils (0.018 mm).

1. Shop Primer: Manufacturer’s standard, fast-curing, lead- and chromate-free primer complying with ANSI A250.10 acceptance criteria; recommended by primer manufacturer for substrate; compatible with substrate and field-applied finish paint system indicated; and providing a sound foundation for field-applied topcoats despite prolonged exposure.

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 sound-control door assemblies.

1. Examine roughing-in for embedded and built-in anchors to verify actual locations of sound-control door frame connections before frame installation.
2. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of work.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Remove welded-in shipping spreaders installed at factory.

B. Prior to installation and with installation spreaders in place, adjust and securely brace sound-control door frames for squareness, alignment, twist, and plumb 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 non-templated mortised and surface-mounted door hardware.

### INSTALLATION

#### A. General:
Install sound-control door assemblies plumb, rigid, properly aligned, and securely fastened in place; comply with Drawings and manufacturer's written instructions.

#### B. Frames:
Install sound-control door frames in sizes and profiles indicated.

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. Where frames are fabricated in sections due to shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, dress, make splice smooth, flush, and invisible on exposed faces.
   b. Install sound-control frames with removable glazing stops located on secure side of opening.
   c. Remove temporary braces only after frames or bucks have been properly set and secured.
   d. Check plumb, squareness, and twist of frames as walls are constructed. Shim as necessary to comply with installation tolerances.
   e. Apply bituminous coating to backs of frames that are filled with mortar, grout, and plaster containing antifreezing agents.
   f. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor and secure with postinstalled expansion anchors.
      1) Floor anchors may be set with powder-actuated fasteners instead of postinstalled expansion anchors, if so indicated and approved on Shop Drawings.
   g. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with mortar as specified in Division 04 Section "Reinforced Concrete Unit Masonry."

2. Installation Tolerances: Adjust sound-control 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 on a perpendicular line from head to floor.

C. Doors: Fit sound-control doors accurately in frames, within clearances indicated below. Shim as necessary.

1. Non-Fire-Rated Doors: Fit non-fire-rated doors accurately in frames with the following clearances:

   a. Jambs: 1/8 inch (3 mm).
   b. Head with Butt Hinges: 1/8 inch (3 mm).
   c. Head with Cam-Lift Hinges: As required by manufacturer, but not more than 3/8 inch (9.5 mm).
   d. Sill: Manufacturer's standard.
   e. Between Edges of Pairs of Doors: 1/8 inch (3 mm).

D. Sound-Control Seals: Where seals have been prefit and preinstalled in the factory and subsequently removed for shipping, reinstall seals and adjust according to manufacturer's written instructions.

E. Cam-Lift Hinges: Install hinges according to manufacturer's written instructions.

F. Thresholds: Set thresholds in full bed of sealant complying with requirements in Division 07 Section "Joint Sealants."

3.4 FIELD QUALITY CONTROL

A. Remove and replace sound-control door assemblies where test results indicate that they do not comply with specified STC rating requirements.

3.5 ADJUSTING AND CLEANING

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

B. Remove and replace defective work, including defective or damaged sound seals and doors and frames that are warped, bowed, or otherwise unacceptable.
1. Adjust gaskets, gasket retainers, and retainer covers to provide contact required to achieve STC rating.

C. Clean grout off sound-control door frames immediately after installation.

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

END OF SECTION 08347
SECTION 08625
TUBULAR DAYLIGHTING DEVICE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Tubular daylighting device, consisting of roof dome, reflective tube, and diffuser assembly; configuration as indicated on the drawings.

B. Accessories.

1.2 RELATED SECTIONS

A. Section 07 – Asphalt Shingles

1.3 REFERENCES


H. ASTM D 635 - Test Method for Rate of Burning and/or Extent of Time of Burning of Self-Supporting Plastics in a Horizontal Position; 2006.

J. UL 181 - Factory Made Air Ducts and Air Connectors

1.4 PERFORMANCE REQUIREMENTS

A. Completed tubular daylighting device assemblies shall be capable of meeting the following performance requirements:

1. Air Infiltration Test: Air infiltration will not exceed 0.30 cfm/sf aperture with a pressure delta of 1.57 psf across the tube when tested in accordance with ASTM E 283.

2. Water Resistance Test: No uncontrolled water leakage at 10.5 psf pressure differential with water rate of 5 gallons/hour/sf when tested in accordance with ASTM E 547.

3. Uniform Load Test:
   a. No breakage, permanent damage to fasteners, hardware parts, or damage to make daylighting system inoperable or cause excessive permanent deflection of any section when tested at a Positive Load of 150 psf (7.18 kPa) or Negative Load of 70 psf (3.35 kPa).
   b. All units shall be tested with a safety factor of (3) for positive pressure and (2) for negative pressure, acting normal to plane of roof in accordance with ASTM E 330.

4. Fire Testing:
   a. When used with the Dome Edge Protection Band, all domes meet fire rating requirements as described in the 2006 International Building Code.
   c. Smoke Density - Rating no greater than 450 Per U.B.C. 8-1 (See ASTM Standard E 84) in way intended for use. Classification C.
   d. Rate of Burn and/or Extent - Maximum Burning Rate: 2.5 inches/min (62 mm/min) Classification CC-2: U.B.C. Standard 26-7. See ASTM D 635.
e. Rate of Burn and/or Extent - Maximum Burn Extent: 1-inch (25 mm) Classification CC-1: U.B.C. Standard 26-7. See ASTM D 635.

1.5 SUBMITTALS

A. Submit under provisions of Section 01300.

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

C. Shop Drawings. Submit shop drawings showing layout, profiles and product components, including anchorage, flashings and accessories.

D. Verification Samples: As requested by Architect.

E. Test Reports: Independent testing agency or evaluation service reports verifying compliance with specified performance requirements.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Engaged in manufacture of tubular daylighting devices for minimum 15 years.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store products in manufacturer's unopened packaging until ready for installation.

B. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.8 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.
1.9  WARRANTY

A.  Daylighting Device: Manufacturer's standard warranty for 10 years.

PART 2 - PRODUCTS

2.1  MANUFACTURERS

A.  Acceptable Manufacturer: Solatube International, Inc., which is located at: 2210 Oak Ridge Way; Vista, CA 92081; Toll Free Tel: 888-765-2882; Tel: 760-477-1120; Email: request info (commsales@solatube.com); Web: www.solatube.com

B.  Requests for substitutions will be considered in accordance with provisions of Section 01600.

2.2  TUBULAR DAYLIGHTING DEVICES

A.  Tubular Daylighting Devices General: Transparent roof-mounted skylight dome and self-flashing curb, reflective tube, and ceiling level diffuser assembly, transferring sunlight to interior spaces; complying with ICBO/ICC AC-16.

B.  SolaMaster Series: Solatube Model 750 DS-C Penetrating Ceiling, 21-inch (530 mm) Daylighting System:

1.  Roof Dome Assembly: Transparent, UV and impact resistant dome with flashing base supporting dome and top of tube.

   a.  Outer Dome Glazing: Type DA, 0.125 inch (3.2 mm) minimum thickness injection molded acrylic classified as CC2 material; UV inhibited, impact modified acrylic blend.

   b.  Inner Dome Glazing: Type DPI, 0.115 inch (3 mm) minimum thickness polycarbonate classified as CC1 material.

2.  Raybender 3000: Variable prism optic molded into outer dome to capture low angle sunlight and limit high angle sunlight.

3.  Roof Flashing Base: One--piece, seamless, leak-proof flashing functioning as base support for dome and top of tube.

   a.  Base Material: Sheet steel, corrosion resistant conforming to ASTM A 653/A 653M or ASTM A 463/A 463M, 0.028 inch (0.7 mm) thick.
b. Base Style: Type FCM, Curb cap, with inside dimensions of 27 inches by 27 inches (685 mm x 685 mm) to cover curb as specified in Section 07600.

c. Flashing Insulator: Type FI, Thermal isolation material for use under flashing.

4. Tube Ring: Attached to top of base section; 0.090 inch (2.3 mm) nominal thickness injection molded high impact PVC; to prevent thermal bridging between base flashing and tubing and channel condensed moisture out of tubing.

5. Dome Seal: Adhesive backed weatherstrip 0.63 inch (16 mm) tall by 0.28 inch (7 mm).

6. Diffuser Assemblies for Tubes Penetrating Ceilings: Solatube Model 750 DS-C. Ceiling mounted box transitioning from round tube to square ceiling assembly, supporting light transmitting surface at bottom termination of tube; 23.8 inches by 23.8 inches (605 mm by 605 mm) square frame to fit standard suspended ceiling grids or hard ceilings.

   a. Round to square transition box made of opaque polymeric material, classified as CC2, Class C, 0.110 inch (2.8 mm) thick.

   b. Lens: Type L2 Prismatic lens design to maximize light output and diffusion with extruded aluminum frame. Visible Light Transmission shall be greater than 90 percent at 0.100 inches (2.5 mm) thick. Classified as CC2.

2.3 ACCESSORIES

A. Fasteners: Same material as metals being fastened, non-magnetic steel, non-corrosive metal of type recommended by manufacturer, or injection molded nylon.

B. Suspension Wire: Steel, annealed, galvanized finish, size and type for application and ceiling system requirement.

C. Sealant: Polyurethane or copolymer based elastomeric sealant as provided or recommended by manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.
B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.2 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.3 INSTALLATION

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

B. After installation of first unit, field test to determine adequacy of installation. Conduct water test in presence of Owner, Architect, or Contractor, or their designated representative. Correct if needed before proceeding with installation of subsequent units.

3.4 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION 08625
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Door Hardware.

B. Related Sections:
   1. Section 06200 - Finish Carpentry: Finish Hardware Installation
   2. Section 07920 – Sealants and Caulking
   3. Section 08111 – Hollow Metal Doors and Frames
   4. Section 08347 – Sound Control Door Assemblies

C. Specific Omissions: Hardware for the following is specified or indicated elsewhere.
   1. Windows.
   2. Cabinets, including open wall shelving and locks.
   3. Signs, except where scheduled.
   4. Toilet accessories, including grab bars.
   5. Installation.
   6. Rough hardware.

1.2 REFERENCES:

Use date of standard in effect as of Bid date.

A. American National Standards Institute – ANSI 156.18 – Materials and Finishes.
B. BHMA – Builders Hardware Manufacturers Association
C. DHI – Door and Hardware Institute
D. NFPA – National Fire Protection Association
   1. NFPA 80 – Fire Doors and Windows
   2. NFPA 105 – Smoke and Draft Control Door Assemblies
   3. NFPA 252 – Fire Tests of Door Assemblies

E. UL – Underwriters Laboratories
   1. UL10C – Positive Pressure Fire Tests of Door Assemblies.
   2. UL 305 – Panic Hardware

F. WHI – Warnock Hersey Incorporated


H. Local applicable codes

I. SDI – Steel Door Institute

J. NAAMM – National Association of Architectural Metal Manufacturers

1.3 SUBMITTALS & SUBSTITUTIONS

A. SUBMITTALS: Submit six copies of schedule per Section 01330. Only submittals printed one sided will be accepted and reviewed. Organize vertically formatted schedule into “Hardware Sets” with index of doors and headings, indicating complete designations of every item required for each door or opening. Include following information:
   1. Type, style, function, size, quantity and finish of hardware items.
   2. Use BHMA Finish codes per ANSI A156.18.
   3. Name, part number and manufacturer of each item.
   4. Fastenings and other pertinent information.
   5. Description of door location using space names and numbers as published in the drawings.
   6. Explanation of abbreviations, symbols, and codes contained in schedule.
   7. Mounting locations for hardware.
   8. Door and frame sizes, handing, materials, fire-rating and degrees of swing.
   9. List of manufacturers used and their nearest representative with address and phone number.
   10. Catalog cuts.
B. Bid and submit manufacturer’s updated/improved item if scheduled item is discontinued.

C. Deviations: Highlight, encircle or otherwise identify deviations from “Schedule of Finish Hardware” on submittal with notations clearly designating those portions as deviating from this section.

D. If discrepancy between drawings and scheduled material in this section, bid the more expensive of the two choices, note the discrepancy in the submittal and request direction from Architect for resolution.

E. Substitutions per Division 1. Include product data and indicate benefit to the Project. Furnish operating samples on request.

F. Items listed with no substitute manufacturers have been requested by Owner to meet existing standard.

G. Furnish as-built/as-installed schedule with closeout documents, including keying schedule, wiring diagrams, manufacturers’ installation, adjustment and maintenance information, and supplier’s final inspection report.

1.4 QUALITY ASSURANCE:

A. Qualifications:

1. Hardware supplier: direct factory contract supplier who employs a certified architectural hardware consultant (AHC), available at reasonable times during course of work for project hardware consultation to Owner, Architect and Contractor.

   a) Responsible for detailing, scheduling and ordering of finish hardware. Detailing implies that the submitted schedule of hardware is correct and complete for the intended function and performance of the openings.

B. Hardware: Free of defects, blemishes and excessive play. Obtain each kind of hardware (latch and locksets, exit devices, hinges and closers) from one manufacturer.

C. Exit Doors: Operable from inside with single motion without the use of a key or special knowledge or effort.

D. Fire-Rated Openings: NFPA 80 compliant. Hardware UL10C / California State Fire Marshal Standard 12-7-4 (positive pressure) compliant for given type/size opening and degree of label. Provide proper latching hardware, non-flaming door closers, approved-bearing hinges, and resilient seals. Coordinate with wood door section for required intumescent seals. Furnish openings complete.

   1. Note: scheduled resilient seals may exceed selected door manufacturer’s requirements.
2. See 2.6.E for added information regarding resilient and intumescent seals.

E. Furnish hardware items required to complete the work in accordance with specified performance level and design intent, complying with manufacturers’ instructions.

1.5 DELIVERY, STORAGE AND HANDLING:

A. Delivery: coordinate delivery to appropriate locations (shop or field).
   1. Permanent keys and cores: secured delivery direct to Owner’s representative.

B. Acceptance at Site: Items individually packaged in manufacturers’ original containers, complete with proper fasteners and related pieces. Clearly mark packages to indicate contents, locations in hardware schedule and door numbers.

C. Storage: Provide securely locked storage area for hardware, protect from moisture, sunlight, paint, chemicals, dust, excessive heat and cold, etc.

1.6 PROJECT CONDITIONS AND COORDINATION:

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

B. Coordination: Coordinate hardware with other work. Furnish hardware items of proper design for use on doors and frames of the thickness, profile, swing, security and similar requirements indicated, as necessary for proper installation and function, regardless of omissions or conflicts in the information on the Contract Documents. Furnish related trades with the following information:
   1. Manufacturer templates to door and frame fabricators.

C. Check Shop Drawings for doors and entrances to confirm that adequate provisions will be made for proper hardware installation. Do not order hardware until the submittal has been reviewed by the frame and door suppliers for compatibility with their products.
1.7 WARRANTY:

A. Part of respective manufacturers’ regular terms of sale. Provide manufacturers’ written warranties:

1. Locksets: Three years
2. Exit Devices: Three years mechanical
3. Closers: Ten years mechanical
4. Hinges: One year
5. Continuous Hinges Life of the Installation
6. Other Hardware Two years

1.8 COMMISSIONING:

A. Conduct these tests prior to request for certificate of substantial completion:

1. With installer present, test door hardware operation with climate control system both at rest and while in full operation.
PART 2 PRODUCTS

2.1 MANUFACTURERS:

A. Listed acceptable alternate manufacturers: submit for review products with equivalent function and features of scheduled products.

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2.2 HINGING METHODS:

A. Drawings typically depict doors at 90 degrees, doors will actually swing to maximum allowable. Use wide-throw conventional or continuous hinges as needed up to 8 inches in width to allow door to stand parallel to wall for true 180-degree opening. Advise architect if 8-inch width is insufficient.

B. Conform to manufacturer’s published hinge selection standard for door dimensions, weight and frequency, and to hinge selection as scheduled. Where manufacturer’s standard exceeds the scheduled product, furnish the heavier of the two choices, notify Architect of deviation from scheduled hardware.

C. Conventional Hinges: Steel or stainless-steel pins and concealed bearings. Hinge open widths minimum, but of sufficient throw to permit maximum door swing.

1. Outswinging exterior doors: non-ferrous with non-removable (NRP) pins and security studs.

2. Non-ferrous material exteriors and at doors subject to corrosive atmospheric conditions.
D. Continuous Hinges:

1. Geared-type aluminum.
   a) Use wide-throw units where needed for maximum degree of swing, advise architect if commonly available hinges are insufficient.
   b) If units are used at storefront openings, color-coordinate hinge finish with storefront color. Custom anodizing and custom powdercoat finishes subject to Architect approval.

2. At masonry construction, coordinate with the anchoring and hollow metal supplier prior to frame installation by placing a strip of insulation on the back of the hollow metal frame behind the rabbet section. When the frame is grouted in place, the backing will allow drilling and tapping without dulling or breaking the installer’s bits.

2.3 LOCKSETS, LATCHSETS, DEADBOLTS:

A. Mortise Locksets and Latchsets: Shall be Schlage L9000 Series as scheduled.

1. Chassis: cold-rolled steel, handing field-changeable without disassembly.
2. Latchbolts: 3/4 inch throw stainless steel anti-friction type.
3. Lever Trim: through-bolted, accessible design, cast lever or solid extruded bar type levers as scheduled. Filled hollow tube design unacceptable.
   a) Spindles: security design independent breakaway. Breakage of outside lever does not allow access to inside lever’s hubworks to gain wrongful entry.
   b) Inside lever applied by screwless shank mounting – no exposed trim mount screws.
   c) Outside and inside trim thru-bolted together and through the door.
4. Spring-loaded fusible link provides fail secure mode in case of fire.
5. Universal lock case – 10 functions in one case.
6. Floating mounting tabs automatically adjusts to fit a beveled door edge.
7. Field reversible handing without opening lock case.
8. External spring cages allow for simple trim retrofit.
9. Lever rotation in both directions (up & down) for ease of use.
10. At Vandlgard locks, locked lever freely rotates down while remaining securely locked. This feature prevents damage to internal lock components when subjected to excessive force.
11. Independent lever rotation.
12. Furnish solid cylinder collars with wave springs. Wall of collar to cover rim of mortise cylinder.
13. Thumbturns: accessible design not requiring pinching or twisting motions to operate.
15. Strikes: 16 gage curved steel, bronze or brass with 1 inch deep box construction, lips of sufficient length to clear trim and protect clothing.
17. Certifications:
   a) ANSI A156.13, 1994, Grade 1 Operational, Grade 1 Security.
   b) ANSI/ASTM F476-84 Grade 31 UL Listed.

2.4 EXIT DEVICES / PANIC HARDWARE

A. General features: Shall be Von Duprin 98 Series as scheduled.
1. Independent lab-tested 1,000,000 cycles.
3. 0.75-inch throw deadlocking latchbolts.
4. End caps: impact-resistant, flush-mounted. No raised edges or lips to catch carts or other equipment.
5. No exposed screws to show through glass doors.
6. Non-handed basic device design with center case interchangeable with all functions, no extra parts required to effect change of function.
7. Releasable in normal operation with 15-lb. maximum operating force per California State Fire Marshal Standard 12-10-3, and with 32 lb. maximum pressure under 250-lb. load to the door.
9. Where devices span over door lite frame and the face of the selected lite manufacturer’s frame is raised from the face of the door, furnish panic hardware manufacturer’s fitted shims or glass-bead kits at no additional cost to the project.
10. Comply with CBC Section 1003.3.1.9.
B. Specific features:

1. Removable Mullions: Removable with single turn of building key. Securely reinstalled without need for key. Furnish storage brackets for securely stowing the mullion away from the door when removed.

2.5 CLOSERS

A. Surface Closers:

1. Full rack-and-pinion type cylinder with removable non-ferrous cover and cast iron body. Double heat-treated pinion shaft, single piece forged piston, chrome-silicon steel spring.

2. ISO 2000 certified. Units stamped with date-of-manufacture code.

3. Independent lab-tested 10,000,000 cycles.


5. Plates, brackets and special templating when needed for interface with particular header, door and wall conditions and neighboring hardware.

6. Adjustable to open with not more than 5.0lbs pressure to open at exterior doors and 5.0lbs at interior doors. As allowed per California Building Code, Section 1133B.2.5, local authority may increase the allowable pressure for fire doors to achieve positive latching, but not to exceed 15lbs.

7. When provided, the sweep period of the closer shall be adjusted so that from an open position of 70 degrees, the door will take at least 3 seconds to move to a point 3 inches from the latch, measured to the landing side of the door.

8. Separate adjusting valves for closing speed, latching speed and backcheck, fourth valve for delayed action where scheduled.

9. Extra-duty arms (EDA) at exterior doors scheduled with parallel arm units. EDA arms: rigid main and forearm, reinforced elbow.

10. Exterior door closers: tested to 100 hours of ASTM B117 salt spray test, furnish data on request.

11. Exterior doors: seasonal adjustments not required for temperatures from 120 degrees F to -30 degrees F, furnish checking fluid data on request.

12. Non-flaming fluid, will not fuel door or floor covering fires.

13. Pressure Relief Valves (PRV) not permitted.
2.6 OTHER HARDWARE

A. Kick Plates: Rounded and relieved edges, .050 inches minimum thickness, height and width as scheduled. Sheet-metal screws of bronze or stainless steel to match other hardware.

B. Seals: Finished to match adjacent frame color. Resilient seal material: polyurethane, polypropylene, nylon brush, silicone rubber or solid high-grade neoprene as scheduled. Do not furnish vinyl seal material. UL label applied to seals on rated doors. Substitute products: certify that the products equal or exceed specified material’s thickness and durability.
   1. Proposed substitutions: submit for approval.
   3. Non-corroding fasteners at in-swinging exterior doors.
   4. Fire-rated Doors, Resilient Seals: UL10C / UBC Standard 7-2 compliant. Coordinate with selected door manufacturers' and selected frame manufacturers' requirements. Where rigid housed resilient seals are scheduled in this section and the selected door manufacturer only requires an adhesive-mounted resilient seal, furnish rigid housed seal at minimum, or both the rigid housed seal plus the adhesive applied seal. Adhesive applied seals alone are deemed insufficient for this project where rigid housed seals are scheduled.

C. Thresholds: As scheduled and per details. Comply with CBC Section 1133B.2.4.1. Substitute products: certify that the products equal or exceed specified material’s thickness. Proposed substitutions: submit for approval.
   1. Exteriors: Seal perimeter to exclude water and vermin. Use sealant complying with requirements in Division 7 "Thermal and Moisture Protection". Non-ferrous 1/4inch fasteners and lead expansion shield anchors, or Red-Head #SFS-1420 (or approved equivalent) Flat Head Sleeve Anchors (SS/FHSL).
   2. Flat saddle type thresholds shall have a minimum wall thickness of .125”.
   3. Fire-rated openings, 90min or less duration: use thresholds to interrupt floor covering material under the door where that material has a critical radiant flux value less than 0.22 watts per square centimeter, per NFPA 253. Use threshold unit as scheduled. If none scheduled, request direction from Architect.
   4. Plastic plugs with wood or sheet metal screws are not an acceptable substitute for specified fastening methods.
5. Fasteners: Generally, exposed screws to be Phillips or Robertson drive. Pinned TORX drive at high security areas. Flat head sleeve anchors (FHSL) may be slotted drive. Sheet metal and wood screws: full-thread. Sleeve nuts: full length to prevent door compression.

D. Exposed Through-Bolts: Do not use SNB, grommet nuts, sleeve nuts or other such clamping type fasteners, intent is for minimal exposed hardware. Coordinate with wood doors; ensure provision of proper blocking to support wood screws for mounting panic hardware and door closers. Coordinate with metal doors and frames; ensure provision of proper reinforcement to support machine screws for mounting panic hardware and door closers.

2.7 FINISH:

A. Generally BHMA 626 Satin Chromium or BHMA 630 Satin Stainless Steel.
   1. Areas using BHMA 626 to have push-plates, pulls and protection plates of BHMA 630, Satin Stainless Steel, unless otherwise noted.

B. Door closers: factory powder coated to match other hardware, unless otherwise noted.

C. Aluminum items: match predominant adjacent material. Seals to coordinate with frame color.

2.8 KEYING REQUIREMENTS:

A. Key System: Schlage Everest utility-patented keyway, interchangeable core. Utility patent protection to extend at least until 2014. Key blanks available only from factory-direct sources, not available from after-market key blank manufacturers. For estimate use factory GMK charge. Initiate and conduct meeting(s) with Owner to determine system keyway(s), keybow styles, structure and degree of geographic exclusivity. Furnish Owner’s written approval of the system. Owner/Contractor will install permanent cores (to be determined).

B. Keys
   1. Existing factory registered master key system.
   2. Construction keying: furnish temporary keyed-alike cores. Remove at substantial completion and install permanent cylinders/cores in Owner’s presence. Demonstrate that construction key no longer operates.
   3. Furnish 10 construction keys.
   4. Furnish 2 construction control keys.

C. Key Cylinders: furnish utility patented, 6-pin solid brass construction.
D. Cylinder cores: furnish keyed at factory of lock manufacturer where permanent records are maintained. Locks and cylinders same manufacturer.

E. Permanent keys: use secured shipment direct from point of origination to Owner.
   1. For estimate: 3 keys per change combination, 5 master keys per group, 5 grand-master keys, 3 control keys.
   2. For estimate: VKC stamping plus “Do Not Duplicate”.

F. Bitting List: use secured shipment direct from point of origination to Owner upon completion.

PART 3 - EXECUTION

3.1 ACCEPTABLE INSTALLERS:

A. Can read and understand manufacturers’ templates, suppliers’ hardware schedules and printed installation instructions. Can readily distinguish drywall screws from manufacturers’ furnished fasteners. Available to meet with manufacturers’ representatives and related trades to discuss installation of hardware.

3.2 PREPARATION:

A. Ensure that walls and frames are square and plumb before hardware installation. Make corrections before commencing hardware installation.

B. Locate hardware per SDI-100 and applicable building, fire, life-safety, accessibility, and security codes.
   1. Notify Architect of code conflicts before ordering material.
   2. Locate levers, key cylinders, t-turn pieces, touchbars and other operable portions of latching hardware between 30 inches to 44 inches above the finished floor, per CBC Section 1133B.2.5.2.
3.3 INSTALLATION

A. Install hardware per manufacturer’s instructions and recommendations. Do not install surface-mounted items until finishes have been completed on substrate. Set units level, plumb and true to line and location. Adjust and reinforce attachment substrate for proper installation and operation. Remove and reinstall or replace work deemed defective by Architect.

1. Gaskets: install jamb-applied gaskets before closers, overhead stops, rim strikes, etc; fasten hardware over and through these seals. Install sweeps across bottoms of doors before astragals, cope sweeps around bottom pivots, trim astragals to tops of sweeps.

2. Use manufacturers’ fasteners furnished with hardware items or submit Request for Substitution with Architect.

3. Replace fasteners damaged by power-driven tools.

3.4 ADJUSTING

A. Adjust and check for proper operation and function. Replace units, which cannot be adjusted to operate freely and smoothly.

1. Hardware damaged by improper installation or adjustment methods: repair or replace to Owner’s satisfaction.

2. Adjust doors to fully latch with no more than 1 pound of pressure.

B. Final inspection: Installer to provide letter to Owner that upon completion installer has visited the Project and has accomplished the following:

1. Re-adjust hardware.

2. Evaluate maintenance procedures and recommend changes or additions and instruct Owner’s personnel.

3. Identify items that have deteriorated or failed.

4. Submit written report identifying problems

3.5 DEMONSTRATION:

A. Demonstrate mechanical hardware systems, including adjustment and maintenance procedures.
3.6 PROTECTION/CLEANING:

A. Cover installed hardware, protect from paint, cleaning agents, weathering, carts/barrows, etc. Remove covering materials and clean hardware just prior to substantial completion.

B. Clean adjacent wall, frame and door surfaces soiled from installation/reinstallation process.

3.7 SCHEDULE OF FINISH HARDWARE

A. See door schedule in drawings for hardware set assignments.

B. Manufacturers and their abbreviations used in this schedule:

IVE H.B. Ives

LCN LCN Closers

NGP National Guard Products

SCH Schlage Lock Company

VON Von Duprin

SPECWORKS # 105777

HW SET: 001

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<td>630</td>
<td>IVE</td>
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<tr>
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<td>SEALS</td>
<td>160S</td>
<td>AL</td>
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<tr>
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<td>DOOR SWEEP</td>
<td>200NA</td>
<td>CL</td>
<td>NGP</td>
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<tr>
<td>1</td>
<td>EA</td>
<td>THRESHOLD</td>
<td>THRESHOLD PER DETAIL</td>
<td>AL</td>
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<tr>
<td>1</td>
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<td>LOCK GUARD</td>
<td>LG12</td>
<td>600</td>
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HW SET: 002

3 EA Hinge 3CB1 4.5 X 4.5 NRP SH 630 IVE
1 EA Indicator Priv Lock LV9486T 17A L583-375 & L583-363 X 2 EMERGENCY KEYS 630 SCH
1 EA Core Only 23-030 626 SCH
1 EA Surface Closer 4111 CUSH 689 LCN
1 EA Kick Plate 8400 10" X 2" LDW 630 IVE
1 SET Seals 160S AL NGP
1 EA Door Sweep 200NA CL NGP
1 EA Threshold Threshold Per Detail AL NGP
1 EA Lock Guard LG12 600 IVE

HW SET: 003

2 EA Continuous Hinge 224HD 628 IVE
1 EA Mullion KR9954 689 VON
1 EA Fire Exit Hardware XP98EO-F X 499F Strike 630 VON
1 EA Fire Exit Hardware XP98NL-F X 499F Strike 630 VON
1 EA Rim Cylinder 20-057-ICX 626 SCH
1 EA Mortise Cylinder 20-061-ICX For Mullion 626 SCH
2 EA Core Only 23-030 626 SCH
1 SET Astragal 140PA 84" CL NGP
1 EA Mullion Seal 5100 BLK NGP
2 EA Surface Closer 4111 CUSH 689 LCN
2 EA Kick Plate 8400 10" X 2" LDW 630 IVE
1 SET Seals 160S AL NGP
1 SET Seals 160S For Mullion AL NGP
2 EA Door Sweep 200NA CL NGP
1 EA Threshold Threshold As Required For Fire Rating AL NGP

HW SET: 004

3 EA Hinge 3CB1 4.5 X 4.5 NRP 630 IVE
1 EA Classroom Lock L9070T 17A 630 SCH
1 EA Core Only 23-030 626 SCH
1 EA Surface Closer 4111 CUSH 689 LCN
1 EA Kick Plate 8400 10" X 2" LDW 630 IVE
1 SET Seals 160S AL NGP
1 EA Threshold Threshold As Required For Fire Rating AL NGP
END OF SECTION 08711
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 the following:
   1. Interior gypsum board.
   2. Tile backing panels.

B. Related Sections include the following:
   1. Division 06 Section "Rough Carpentry" for wood framing and furring that supports gypsum board.
   2. Division 09 painting Sections for primers applied to gypsum board surfaces.

1.3 SUBMITTALS

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

B. Samples: For the following products:
   1. Trim Accessories: Full-size Sample in 12-inch- (300-mm-) long length for each trim accessory indicated.
   2. Textured Finishes: Manufacturer's standard size for each textured finish indicated and on same backing indicated for Work.

1.4 QUALITY ASSURANCE

A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing agency.
1.5 STORAGE AND HANDLING

A. Store materials inside under cover and keep them dry and protected against damage from weather, condensation, direct sunlight, construction traffic, and other causes. Stack panels flat to prevent sagging.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Comply with ASTM C 840 requirements or gypsum board manufacturer's written recommendations, whichever are more stringent.

B. Do not install interior products until installation areas are enclosed and conditioned.

C. Do not install panels that are wet, those that are moisture damaged, and those that are mold damaged.

1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.

2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.1 PANELS, GENERAL

A. Size: Provide in maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.

2.2 INTERIOR GYPSUM BOARD

A. General: Complying with ASTM C 36/C 36M or ASTM C 1396/C 1396M, as applicable to type of gypsum board indicated and whichever is more stringent.

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 following:

   a. American Gypsum Co.
   b. BPB America Inc.
   c. G-P Gypsum.
   d. Lafarge North America Inc.
   e. National Gypsum Company.
f. PABCO Gypsum.
g. Temple.
h. USG Corporation.

B. Ceiling Type: Manufactured to have more sag resistance than regular-type gypsum board.

1. Thickness: 1/2 inch (12.7 mm).
2. Long Edges: Tapered.

C. Moisture- and Mold-Resistant Type: With moisture- and mold-resistant core and surfaces.

1. Core: 5/8 inch (15.9 mm), Type X.
2. Long Edges: Tapered.

2.3 TILE BACKING PANELS

A. Water-Resistant Gypsum Backing Board: ASTM C 630/C 630M or ASTM C 1396/C 1396M.

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

a. American Gypsum Co.
b. BPB America Inc.
c. G-P Gypsum.
d. Lafarge North America Inc.
e. National Gypsum Company.
f. PABCO Gypsum.
g. Temple.
h. USG Corporation.

3. Core: 5/8 inch (15.9 mm), Type X.

B. Glass-Mat, Water-Resistant Backing Board:

1. Complying with ASTM C 1178/C 1178M.

a. Product: Subject to compliance with requirements, provide "DensShield Tile Guard" by G-P Gypsum.
2. Complying with ASTM C1177/C 1177M.
   a. Product: Subject to compliance with requirements, provide "DensArmor Plus Interior Guard" by G-P Gypsum.

3. Core: 5/8 inch (15.9 mm), Type X.

2.4 TRIM ACCESSORIES

A. Interior Trim: ASTM C 1047.
   1. Material: Galvanized or aluminum-coated steel sheet or rolled zinc
   2. Shapes:
      a. Cornerbead.
      b. LC-Bead: J-shaped; exposed long flange receives joint compound.
      c. L-Bead: L-shaped; exposed long flange receives joint compound.

   1. Material: Hot-dip galvanized steel sheet, plastic, or rolled zinc
   2. Shapes:
      a. Cornerbead.
      b. LC-Bead: J-shaped; exposed long flange receives joint compound.
      c. Expansion (Control) Joint: One-piece, rolled zinc with V-shaped slot and removable strip covering slot opening.

2.5 JOINT TREATMENT MATERIALS

A. General: Comply with ASTM C 475/C 475M.

B. Joint Tape:
   1. Interior Gypsum Wallboard: Paper.
   2. Tile Backing Panels: As recommended by panel manufacturer.

C. Joint Compound for Interior Gypsum Wallboard: For each coat use formulation that is compatible with other compounds applied on previous or for successive coats.
   1. Prefilling: At open joints and damaged surface areas, use setting-type taping compound.
   2. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use setting-type taping compound.
Gypsum Board
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a. Use setting-type compound for installing paper-faced metal trim accessories.

3. Fill Coat: For second coat, use setting-type, sandable topping compound.
4. Finish Coat: For third coat, use setting-type, sandable topping compound.

D. Joint Compound for Tile Backing Panels:

1. Water-Resistant Gypsum Backing Board: Use setting-type taping compound and setting-type, sandable topping compound.
2. Glass-Mat, Water-Resistant Backing Panel: As recommended by backing panel manufacturer.

2.6 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards and manufacturer's written recommendations.

B. Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.

1. Use adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Steel Drill Screws: ASTM C 1002, unless otherwise indicated.

1. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch (0.84 to 2.84 mm) thick.
2. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.

D. Thermal Insulation: As specified in Division 07 Section "Thermal Insulation."

E. Vapor Retarder: As specified in Division 07 Section "Thermal Insulation."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames and framing, for compliance with requirements and other conditions affecting performance.
B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.

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

3.2 APPLYING AND FINISHING PANELS, GENERAL

A. Comply with ASTM C 840.

B. Install ceiling panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.

C. Install panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch (1.5 mm) of open space between panels. Do not force into place.

D. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.

E. Form control and expansion joints with space between edges of adjoining gypsum panels.

F. Cover both faces of support framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.

1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. (0.7 sq. m) in area.

2. Fit gypsum panels around ducts, pipes, and conduits.

3. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4- to 3/8-inch- (6.4- to 9.5-mm-) wide joints to install sealant.

G. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments, except floors. Provide 1/4- to 1/2-inch- (6.4- to 12.7-mm-) wide spaces at these locations, and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.

H. Wood Framing: Install gypsum panels over wood framing, with floating internal corner construction.
Do not attach gypsum panels across the flat grain of wide-dimension lumber, including floor joists and headers. Float gypsum panels over these members or provide control joints to counteract wood shrinkage.

3.3 APPLYING INTERIOR GYPSUM BOARD

A. Install interior gypsum board in the following locations:
   1. Type X: As indicated on Drawings
   2. Ceiling Type: As indicated on Drawings.
   3. Moisture- and Mold-Resistant Type: Restroom.

B. Single-Layer Application:
   1. On ceilings, apply gypsum panels before wall/partition board application to greatest extent possible and at right angles to framing, unless otherwise indicated.
   2. On partitions/walls, apply gypsum panels vertically (parallel to framing), unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.
      a. Stagger abutting end joints not less than one framing member in alternate courses of panels.
   3. Fastening Methods: Apply gypsum panels to supports with steel drill screws.

3.4 APPLYING TILE BACKING PANELS

A. Water-Resistant Gypsum Backing Board: Install at showers, tubs, and where indicated. Install with 1/4-inch (6.4-mm) gap where panels abut other construction or penetrations.

B. Glass-Mat, Water-Resistant Backing Panel: Comply with manufacturer’s written installation instructions and install at locations indicated to receive tile. Install with 1/4-inch (6.4-mm) gap where panels abut other construction or penetrations.

C. Areas Not Subject to Wetting: Install regular-type gypsum wallboard panels to produce a flat surface except at showers, tubs, and other locations indicated to receive water-resistant panels.

D. Where tile backing panels abut other types of panels in same plane, shim surfaces to produce a uniform plane across panel surfaces.
3.5 INSTALLING TRIM ACCESSORIES

A. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.

B. Interior Trim: Install in the following locations:

1. Cornerbead: Use at outside corners.
2. LC-Bead: Use at exposed panel edges.

3.6 FINISHING GYPSUM BOARD

A. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.

B. Prefill open joints and damaged surface areas.

C. Apply joint tape over gypsum board joints, except those with trim having flanges not intended for tape.

D. Gypsum Board Finish Levels: Finish panels to levels indicated below and according to ASTM C 840:

1. Level 1: Ceiling plenum areas, concealed areas, and where indicated.
2. Level 2: Panels that are substrate for tile.
3. Level 4: At panel surfaces that will be exposed to view, unless otherwise indicated.

   a. Primer and its application to surfaces are specified in other Division 09 Sections.

E. Glass-Mat, Water-Resistant Backing Panels: Finish according to manufacturer's written instructions.

3.7 PROTECTION

A. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.

B. Remove and replace panels that are wet, moisture damaged, and mold damaged.
1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION 09290
# SPECIFICATIONS - DETAILED PROVISIONS

Section 09871 - Coating System for Water Pumping Plants

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<td>3.05 WARRANTY INSPECTION</td>
<td></td>
<td>8</td>
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</tbody>
</table>
PART 1 - GENERAL

1.01 DESCRIPTION
The work included in this section consists of the furnishing of all labor, materials, apparatus, scaffolding, and all appurtenant work in connection with painting, in accordance with these specifications.

A. Work Included. In general, the following surfaces are to be painted or coated (including interior "linings"): 
   1. Exposed piping and other ferrous metal surfaces, interior and exterior.
   2. All structural and miscellaneous steel.
   3. All specifically designated concrete surfaces.
   4. Equipment furnished without factory finished surfaces.
   5. All pumps and piping.

B. Related Work Not Included. In general, the following surfaces shall not be painted:
   1. Non-ferrous metals unless otherwise noted or indicated, and fiberglass. (Galvanized metal shall not be considered a non-ferrous metal.)
   2. Concrete surfaces subject to pedestrian traffic.
   3. Electrical and mechanical equipment furnished with baked enamel surface and exempted by the District.

C. Paint Required. In no case shall any concrete, wood, metal, or any other surface requiring protection be left unpainted even though not specifically defined herein.

D. Protection of the Work
   1. The Contractor shall take the necessary steps to protect the work of others during the time his work is in progress. The Contractor shall be responsible for any and all damage to the work.
2. Motors, pumps, and other equipment that might be damaged by sandblasting and that are furnished with approved, factory-applied finish shall be solvent cleaned, lightly sanded, and given one (1) coat of Dutch Boy Epicote Finish No. 26-66. The District shall be the final judge as to which equipment the above requirement applies. Color shall be as determined by the District.

1.02 QUALITY ASSURANCE

A. Materials

1. Paint. All materials specified by name and/or manufacturer, or selected for use under these specifications shall be delivered unopened at the job site in their original containers and shall not be opened until inspected by the Engineer. Whenever a manufacturer's brand name is specified, it is intended to define the general type and quality of paint desired. Other paints of equal quality may be used only with written approval of the District. No paint, varnish, or stain shall be reduced or applied in any way, except as herein specifically called for or if not specifically called for, then it shall be applied in accordance with the manufacturer's recommendations.

   a) Heavy Metals including lead, chromates and mercury are not permitted. Any coating containing toxics that require hazardous waste treatment or disposal are not permitted.

2. Fusion Bonded Epoxy Linings (and coatings). Epoxy shall be applied to all metal as designated in accordance with AWWA Standard C-213-79 by either fluidized bed application or electrostatic spray application. The minimum dry coating thickness shall be 8 mils provided however, that the thickness of coating in the grooves for valves of fittings designed to receive a rubber gasket shall be approximately 5 mils.

3. Liquid Epoxy. Where the size of the valve or other item is too large to be lined by the powder epoxy method, it shall be prepared in accordance with the requirements of AWWA Specification D102-78 Inside System No. 1 and lining shall conform to the following requirements:

   a) Thickness of Lining. The epoxy shall be applied in 2-5 spray coats to a minimum dry film thickness of 8 mils.

   b) Application and Cure. The first coat of liquid epoxy shall be spray applied to the prepared surface within four (4) hours after completion of sandblasting. All items to be coated and the epoxy to be applied shall be at a temperature of 50° F. at the time of application. The first coat shall be air-dried at room temperature twenty-four (24) hours prior to application of the second coat; all items shall be air-cured with adequate ventilation for seven (7) days at a temperature of 65° F.
B. **Color Selection.** All color selections shall be subject to approval of submittals by the District.

C. **Primer and Intermediate Coats.** Primer and intermediate coats of paint shall be unscarred and completely integral at the time of application of each succeeding coat. Each coat shall be subject to the inspection and approval of the Engineer before the next succeeding coat is applied, and defective work of any kind shall be deemed sufficient cause for recoating the entire surface involved.

Sufficient time shall be allowed between coats to insure proper drying, unless these specifications or manufacturer's recommendations specifically state otherwise. Excessive time or exposure between coats shall not occur in cases where such excessive time or exposure will impair the bond between coats.

### 1.03 SUBMITTALS
Submit samples of field-applied paint and coating finishes, colors, and covering at least sixty (60) days prior to start of such finishing operations.

A. **Identification.** Label or tag each sample or set of samples identifying the manufacturer's name and address, brand name, catalog number, project title, and intended use.

B. **Colors, Patterns, and Textures.** For items required to be of selected and approved colors, patterns, textures, or other finish, submit sufficient samples to show the range of shades, tones, values, patterns, textures, or other features corresponding to the instructions and requirements specified.

C. **Factory Finish Colors.** Colors of material specified to be furnished with a factory finish are subject to approval. Submit duplicate samples of factory finishes showing the full range of available colors for selection and approval.

### PART 2 - PRODUCTS AND MATERIALS

#### 2.01 PROTECTIVE COATING MATERIALS

| P1   | Alkyd rust-inhibitive primer | Amercoat 25  |
|      |                               | Carbocoat 150 |
|      |                               | Tnemec 413    |

| P2   | Alkyd finish                  | Amercoat 52  |
|      |                               | Carbocoat 139|
|      |                               | Tnemec 2     |

| P3   | Rubber primer                 | Polyken Plicoflex |
### Coating System for Water Pumping Plants

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#### 2.01 PROTECTIVE COATING MATERIALS – cont’d

<table>
<thead>
<tr>
<th>No.</th>
<th>Type</th>
<th>Materials</th>
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<tbody>
<tr>
<td>P4</td>
<td>PVC 20-mil tape (AWWA C214-83)</td>
<td>Polyken tape, Plicoflex tape</td>
</tr>
<tr>
<td>P5</td>
<td>Coal Tar Epoxy</td>
<td>Amercoat 78, Carboline Bitumastic 300M, Tnemec 413</td>
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<td>P6</td>
<td>Coal Tar Mastic</td>
<td>Carboline Bitumastic 50</td>
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<td>P7</td>
<td>Universal Primer</td>
<td>Carbocrylic 120, Amercoat 38, Tnemec 77 Chem-Prime</td>
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<tr>
<td>P8</td>
<td>Grease</td>
<td>Chevron E.P. Roller Grease or Texaco Rust Inhibitive Grease</td>
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<tr>
<td>P9</td>
<td>Epoxy</td>
<td>Amercoat 74, Carboguard 890, Tnemec 66</td>
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<tr>
<td>P10</td>
<td>Vinyl Wash Primer</td>
<td>Amercoat 59, Rustbond Penetrating Sealer, Tnemec 32-1210</td>
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<tr>
<td>P11</td>
<td>Epoxy Coating - Powder</td>
<td>3M Scotch Coat, Dow DC 3100, Furane 2611</td>
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<td>P12</td>
<td>Epoxy Coating – Liquid (AWWA Std. D102-78 Inside System No. 1)</td>
<td>Keysite 750, Tnemec Series 20, Engard 460 H.S., Carboguard 891</td>
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<td>P13</td>
<td>Waterproofing</td>
<td>Regular Rainguard, Regular Penetreat-50, Rainproof</td>
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<td>P14</td>
<td>Field Applied Finish Coat</td>
<td>Dutch Boy Epicote No. 26-66</td>
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<td>P15</td>
<td>Acrylic Latex</td>
<td>Prufcoat - Prufacryl 556 Series, Devoe 12XX</td>
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2.02 SURFACE PREPARATION AND COATING THICKNESS

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<tr>
<th>ITEM</th>
<th>SURFACE PREPARATION</th>
<th>FIRST COAT</th>
<th>SECOND COAT</th>
<th>THIRD COAT</th>
<th>MIN. TOTAL DRY FILM THICKNESS (MLS)</th>
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<tbody>
<tr>
<td>1.</td>
<td>Ferrous Metal Surfaces</td>
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</tr>
<tr>
<td>A.</td>
<td>Exposed</td>
<td>SP65</td>
<td>P15</td>
<td>P2</td>
<td>P2</td>
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<tr>
<td>B.</td>
<td>Submerged Non-Potable</td>
<td>SP10</td>
<td>P5</td>
<td>P5</td>
<td>---</td>
</tr>
<tr>
<td>C.</td>
<td>Submerged Potable</td>
<td>SP10</td>
<td>P11 or P12</td>
<td>P11 or P12</td>
<td>---</td>
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<tr>
<td>D.</td>
<td>Underground</td>
<td>SP3</td>
<td>P6</td>
<td>P6</td>
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<tr>
<td>E.</td>
<td>Subjected to High Temp. (300°+ F)</td>
<td>SP6</td>
<td>P9</td>
<td>P9</td>
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<td>Wearing Surfaces</td>
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<tr>
<td>2.</td>
<td>Steel Pipe</td>
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<tr>
<td>A.</td>
<td>Exterior (if not CML)</td>
<td>SP10</td>
<td>P11 or P12</td>
<td>P11 or P12</td>
<td>---</td>
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<tr>
<td>B.</td>
<td>Exterior (if concrete encased)</td>
<td>SP3</td>
<td>P1</td>
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<tr>
<td>C.</td>
<td>Exterior (if not CMC or concrete encased)</td>
<td>(Coated and wrapped per current AWWA C-203)</td>
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<td>3.</td>
<td>Ferrous Metal Valves</td>
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</tr>
<tr>
<td>A.</td>
<td>Exterior</td>
<td>(As described for Item 1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.</td>
<td>Interior</td>
<td>SP10</td>
<td>P11 or P12</td>
<td>P11 or P12</td>
<td>---</td>
</tr>
<tr>
<td>4.</td>
<td>Black Steel Pipe (Buried; Exterior)</td>
<td>SP3</td>
<td>P3</td>
<td>P4</td>
<td>---</td>
</tr>
<tr>
<td>5.</td>
<td>Galvanized Surfaces</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.</td>
<td>Coated in addition to galv.</td>
<td>SP3</td>
<td>P10</td>
<td>P2</td>
<td>P2</td>
</tr>
<tr>
<td></td>
<td>Acid Wash &amp; Wash Prime</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.</td>
<td>Buried</td>
<td>SP3</td>
<td>P3</td>
<td>P4</td>
<td>---</td>
</tr>
</tbody>
</table>
### Coating Systems for Water Pumping Plants

09871-6

2.02 SURFACE PREPARATION AND COATING THICKNESS - cont’d

<table>
<thead>
<tr>
<th>ITEM</th>
<th>SURFACE PREPARATION</th>
<th>FIRST COAT</th>
<th>SECOND COAT</th>
<th>THIRD COAT</th>
<th>MIN. TOTAL DRY FILM THICKNESS (MLS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.</td>
<td>Structural Steel</td>
<td>Spot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.</td>
<td>Shop Primed</td>
<td>SP1</td>
<td>P1</td>
<td>P2</td>
<td>P2</td>
</tr>
<tr>
<td>B.</td>
<td>Not Shop Primed</td>
<td>SP3 or SP7</td>
<td>P1</td>
<td>P2</td>
<td>P2</td>
</tr>
<tr>
<td>7.</td>
<td>Mech. Equip. w/Factory Finish</td>
<td>Spot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.</td>
<td>Field Applied Touch-up</td>
<td>SP2</td>
<td>P1</td>
<td>P2</td>
<td>---</td>
</tr>
<tr>
<td>B.</td>
<td>Additional Field</td>
<td>SP3</td>
<td>P16</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>8.</td>
<td>Aluminum Embedded in Concrete</td>
<td>SP1</td>
<td>P6</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>9.</td>
<td>Brass and Copper Alloy</td>
<td>Light Blast using 60 to 80 mesh</td>
<td>P1 (1.5)</td>
<td>P2 (2.5)</td>
<td>P2 (1.5)</td>
</tr>
<tr>
<td>10.</td>
<td>Concrete</td>
<td>Clean Surface</td>
<td>P15</td>
<td>P15</td>
<td>---</td>
</tr>
</tbody>
</table>

**DEFINITIONS**

Exposed: Above ground in pump stations, in pipe galleries, and in buildings.

Submerged: Below the top of walls of water-bearing structures whether below the liquid surface or not. Also includes interior of pipes or locations subjected to splashing and occasional wetting.

Underground: Below the ground surface and surrounded by earth.

**SUPERSCRIPT NOTES**

1. Surfaces of flanged faces shall be coated with red lead just prior to assembly.
2. Omit on shop-primed items and provide surface preparation SP1.
## 2.03 COLOR AND PAINT SCHEDULE

<table>
<thead>
<tr>
<th>PLANT BUILDINGS</th>
<th>ARCHITECTURAL SYSTEM DESIGNATION</th>
<th>DESCRiptive MANUFACTURERS' COLOR CODING</th>
<th>PAINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>General surface</td>
<td>Tan</td>
<td>Rustoleum #865 (Dunes Tan)</td>
<td></td>
</tr>
<tr>
<td>Trim &amp; Doors</td>
<td>Dark Brown</td>
<td>Rustoleum #977 (Chestnut Brown)</td>
<td></td>
</tr>
<tr>
<td>Walls (metal)</td>
<td>Yellow-White</td>
<td>Dunn-Edwards #CH-60B (Parchment)</td>
<td></td>
</tr>
</tbody>
</table>

### PROCESS SYSTEM DESIGNATION

<table>
<thead>
<tr>
<th>PROCESS SYSTEM DESIGNATION</th>
<th>DESCRIPTIVE MANUFACTURERS' COLOR CODING</th>
<th>PAINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>All exposed piping not within building or structures</td>
<td>Desert Tan</td>
<td>Koppers No. 111</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Glamourtex 501</td>
</tr>
</tbody>
</table>

## 2.04 IDENTIFICATION OF PIPING

### A. Piping Systems
Identification of piping systems shall conform to the requirements of ANSI A13.1, "Scheme for the Identification of Piping System", unless otherwise specified herein.

### B. Color Identification
All exposed and/or unburied pipe, including tubing, galvanized pipe, polyvinyl chloride pipe, fiberglass reinforced pipe, and stainless steel pipe, shall be identified by color to show its use function. Color bands of an approved taped type may be used on PVC, FRP, and stainless steel pipe and all other pipe not readily susceptible to painted finish. Markers shall be adhesive type with extra strength and suitable for continuous duty at 250°F. All markers shall have a protective silicone film.
Coating Systems for Water Pumping Plants
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<table>
<thead>
<tr>
<th>ITEM</th>
<th>COLOR CODE</th>
<th>LABEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air, Low Pressure</td>
<td>Light Green</td>
<td>Compressed Air</td>
</tr>
<tr>
<td>(Sherwin Williams F65G4)</td>
<td>(as approp.)</td>
<td>psig</td>
</tr>
<tr>
<td>Air, High Pressure</td>
<td>Light Green w/Yellow</td>
<td>Compressed Air</td>
</tr>
<tr>
<td>(Over 50 psi)</td>
<td>Band (F65G4)</td>
<td>(as approp.) psig</td>
</tr>
<tr>
<td>Gas &amp; LPG</td>
<td>Light Yellow</td>
<td>Gas</td>
</tr>
<tr>
<td>(Sherwin Williams F65Y12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wash Water</td>
<td>Red</td>
<td>Wash Water</td>
</tr>
<tr>
<td>(Sherwin Williams F65R1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pure Water (within bldg.)</td>
<td>Pale Blue</td>
<td>Pure Water</td>
</tr>
<tr>
<td>(Sherwin Williams F65L7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil Lines</td>
<td>Black</td>
<td>Oil</td>
</tr>
<tr>
<td>Chlorine</td>
<td>Safety Orange</td>
<td>Chlorine</td>
</tr>
<tr>
<td>(Sherwin Williams F65E1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Panel</td>
<td>ANSI 61 - Gray</td>
<td>—</td>
</tr>
<tr>
<td>(within bldg.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Conduit and</td>
<td>White</td>
<td>—</td>
</tr>
<tr>
<td>Equipment (except panels)</td>
<td>(Sherwin Williams F65W1)</td>
<td></td>
</tr>
</tbody>
</table>

PART 3 - EXECUTION

3.01 PREPARATION

A. Paint

1. Surface Preparation. The Contractor shall examine carefully all surfaces to be finished and before beginning any of his work shall see that the work of the other trades has been left or installed in a workmanlike condition to receive paint. Metals shall be clean, dry, and free from mill scale, rust, grease, and oil.

2. Except as otherwise provided, all preparation of metal surfaces shall be in accordance with Specifications SP-1 through SP-10 of the Steel Structures Painting Council (SSPC). Grease and oil shall be removed by wiping with mineral spirits or naphtha per Specification SP-1. Rust, scale, welding slag,
and spatter shall be removed by wiping with mineral spirits or naphtha per Specification SP-1. Rust, scale, welding slag, and spatter shall be removed and the surface prepared by hand tool cleaning, power tool cleaning, or blast cleaning in accordance with the appropriate Specification SP-2 through SP-10.

3. **Mixing.** Paint containers shall be opened only when required for use. Paint shall be mixed only in designated rooms or spaces in the presence of the Engineer. Paint shall be thoroughly stirred or agitated to uniformly smooth consistency suitable for proper application. In all cases, paint shall be prepared and handled in a manner to prevent deterioration and inclusion of foreign matter.

**B. Epoxy Coatings.** All oil and grease shall be removed from the metal by caustic degreasing or steam cleaning. The surface shall be sandblasted to near-white metal in accordance with SSPC-SP10. In order to obtain maximum adhesion of epoxy coating, the grit used for blasting shall be coarse enough to impact a tooth in the metal equal to 25% of the thickness of the coating to be applied. The metal shall be cleaned, after sandblasting, with clean, dry compressed air. Use of rags to remove residual dust after sandblasting will not be permitted.

**C. Ventilation.** The Contractor shall not permit painting to begin in enclosed places until a forced draft ventilation system of sufficient air volume has been placed in operation.

### 3.02 APPLICATION OF PAINT

The applicator of the paint shall have had past experience in applying the type or types of coatings and under similar conditions that he will be required to meet in this contract. The Contractor shall verify the paint applicator's qualifications before subcontracting the work to him.

No painting shall be done under dusty conditions, during or immediately after a rain, during rainy weather, or when the temperature is less than 50° F.

Except that prime coats shall be applied by brush and well worked into the surface, paint may be applied by brush, roller, trowel, or spray, unless the manufacturer's recommendations or these specifications call for some particular type of application. Where spray application is used, each coat of paint shall be applied to a thickness equivalent to a brush coat application at a coverage not greater than that specified by the manufacturer for a brush coat application.

All work shall be done in a workmanlike manner, leaving the finished surfaces free from drops, waves, holidays, laps, or brush marks. Drop cloths and other coverings shall be so placed at all times as to protect floors and other surfaces from spatter and droppings. Hardware, plates, lighting fixtures, nameplates, and similar articles which are not to be painted shall be masked off or removed completely. After completion of painting, any spatter or droppings shall be removed.
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The number of coats specified is the minimum to be applied. Suction spots between coats shall be touched up, and additional coats shall be provided if required to produce a finished surface of solid, even color, free from defects. The total thickness of the coating shall be as specified. Additional coats of paint shall be added if necessary to bring the total thickness up to not less than that specified. No holidays shall be left. Particular care shall be used to assure that the specified coverage is secured on the edges and corners of all surfaces. Additional brush coats shall be applied if necessary to cover the edges and corners. The Contractor shall control and check the dry film thickness of the coatings on metal surfaces with a correctly calibrated thickness meter and shall check for holidays with a low-voltage holiday detector. The Engineer may use the Contractor's meter and detector for additional checking.

Damaged paint or scratched painted surfaces shall be sanded smooth before repainting. Sanding and repainting shall be done to such a degree and in such a manner that all evidence of the scratches or damages are obscured.

3.03 CLEAN-UP
Upon completion of his work, the painting contractor shall remove his surplus materials. All paint spills shall be removed and the entire premises shall be free from rubbish, debris, etc. caused by his work. He shall present the work clean and free from blemish so that it is acceptable in every way.

3.04 PAINT TO BE PROVIDED TO DISTRICT
At the end of the project, the Contractor shall turn over to the District a gallon can of each type and color of paint, primer, thinner, or other coating used in the field painting. If the manufacturer packages the material concerned in gallon cans, then it shall be delivered in unopened labeled cans as it comes from the factory. If the manufacturer does not package the material in gallon cans, and in the case of special colors, the materials shall be delivered in new gallon containers, properly closed with typed labels indicating brand, type, color, etc. The manufacturer's literature describing the materials and giving directions for their use shall be furnished in three (3) bound copies. A typewritten inventory list shall be furnished at the time of delivery.

3.05 WARRANTY INSPECTION
Warranty inspection shall be conducted during the eleventh (11th) month following completion of all coating work. All personnel present at the pre-job conference shall be present at this inspection. All defective work shall be repaired in strict accordance with this specification and to the satisfaction of the Engineer.

END OF SECTION 09871
SPECIFICATIONS - DETAILED PROVISIONS
Section 09900 - Painting and Protective Coatings

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PART 1 - GENERAL

1.01 SCOPE

A. Requirements of Conditions of Contract and Division 1 apply to this Section. Provide all labor, materials, apparatus, scaffolding, and all appurtenant work in connection with painting and protective coatings, complete as indicated, specified and required.

B. Work included in this section. Principal items include:

1. All exposed piping, conduits, ducts and other metal surfaces, interior and exterior, except as hereinafter specifically excluded.

2. All submerged and intermittently submerged metal surfaces, except stainless steel.

3. All structural and miscellaneous steel, including tanks.

4. The interior of wet wells, headworks, manholes, junction structures, transition stations and similar structures.

5. Exterior above-ground concrete and concrete block as specified and shown on the Drawings.

6. The interior and exterior of structures as specified in the Painting Schedule and shown on the Drawings.

7. Equipment furnished with and without factory finished surfaces.

8. Equipment on which factory applied finishes have been marred, abraded, scratched, nicked, or otherwise damaged.

9. Exterior and interior concrete, concrete unit masonry, cement plaster, doors, frames, sheet metal surfaces and other architectural work as specified and shown on the Drawings.

10. Protective coating of submerged and intermittently submerged concrete and masonry surfaces, except portion of such surfaces designated to receive waterproofing.
11. Recoating of existing interior and exterior painted surfaces from architectural break where damaged or altered in performance of Work of this General Contract.

C. Related Work Not Included in This Section. The following surfaces, in general, shall not be painted:

1. Concrete surfaces subject to pedestrian or vehicular traffic except as herein specified.

2. Plastic surfaces and fiberglass reinforced plastic (FRP) surfaces, except as specified for identification purposes.

3. Nonferrous metals and stainless steel unless otherwise noted or indicated. Galvanized metal shall not be coated unless specified otherwise.

4. Mechanical equipment with factory finish as specified herein.

5. Electrical and instrumentation equipment with approved factory finish as indicated herein.

6. Waterproofing, damp proofing and roof covering Work.

7. Pavement stripping and marking as specified elsewhere in these Specifications.

8. Existing painted surfaces which are not within areas of alterations performed under this General Contract unless such surfaces are damaged in performance of Work of this General Contract.

D. In no case shall any concrete, wood, metal, or any other surface requiring protection be left unpainted or uncoated even though not specifically defined herein.

1.02 WARRANTY

A. A two (2) year guarantee which commences on the date of acceptance against any failure of coatings shall be provided. Defective coating shall be any of those defined by SSPC's Visual Comparison Manual and include isolated failures. Failure of any coating during the guarantee period shall be repaired by the Contractor who shall absorb all costs related to the repair of the coating.

B. All personnel present at the Pre-Job Conference should attend a warranty inspection. All defective work shall be repaired in strict accordance with this Specification and to the satisfaction of the Engineer.
1. Notification: The Owner shall establish the date for the inspection and shall notify the Contractor at least 30 days in advance. The Contractor shall provide, at his own expense, suitable access equipment, lighting, and ventilation for the inspection.

C. Inspection: all surfaces of the coating systems shall be visually inspected. All defective coatings, as well as damaged or rusting spots, shall be satisfactorily repaired by and at the sole expense of the Contractor. Defective coating shall be any of those defined by SSPC’s Visual Comparison Manual.

1. Inspection Report: the Engineer shall prepare and deliver to the Contractor an inspection report covering the warranty inspection. The report shall set forth the number and type of failures observed, and the names of the persons making the inspection.

2. Schedule: upon completion of the inspection and receipt of Inspection Report as noted herein, Owner shall establish a date for Contractor to proceed with remedial work. Any delay on part of Contractor to meet schedule established by Owner shall constitute breach of this Contract and Owner may proceed to have defects remedied through other means, and these costs may be charged to the Contractor.

3. Remedial Work: any location where coating or paint is defined as defective shall be considered to be a failure of the system at that location. The Contractor shall make repairs at all points where failures are observed by removing the deteriorated coating, cleaning the surface, and recoating or repainting with the same system specified herein. Any spot repairs to defective areas will require feathering at least 3 inches into sound adjacent coating. If an area of failure exceeds 25 percent of a specific coated surface, the entire coating system from that specific area may be required to be removed and recoated in accordance with the original Specification.

1.03 CONTRACTOR

A. The Contractor shall hold a valid State of California Contractor’s Class C-33, Painting and Decorating license for performing surface preparation, cleaning and coating/painting work. The Contractor shall have a minimum of five years’ experience and successful history in the application of the specified products to similar surfaces. The Contractor shall demonstrate said experience by submitting qualifications to the Owner for approval.

B. All coating and surface preparation work shall be performed by skilled personnel demonstrating experience, as listed above. Continuity of personnel shall be maintained
throughout the duration of the cleaning and coating work and any changes in key personnel shall be subject to the approval of the Owner.

C. Applicator Training: Application of coating is considered specialized work. Personnel performing this work shall be trained in proper methods of application.

D. Subcontractor Qualifications: Where the coating is to be applied by a Subcontractor, the Contractor shall provide 5 references, which show that the Subcontractor has previous successful experience with the indicated coating systems in similar applications. Include the name, address, and the telephone number for the owner of each installation for which the Subcontractor provided the coating.

1.04 DEFINITIONS

A. "Lining" refers to protective materials used or applied to interior surfaces, "Paint" refers to protective materials used or applied on exterior surfaces, and "Coating" refers to protective materials used or applied on interior surfaces, or any protective material in general.

B. "Owner" refers to Eastern Municipal Water District. "Engineer" refers to the Inspector, Owner, or the Owner’s designated representative.

1.05 HOURS OF WORK

A. Work areas will be available for performance of the Contract work between 7:00 A.M. and 5:00 P.M. excluding Saturdays, Sundays and holidays. No work shall be accomplished during hours or on days other than specified above, unless approved in advance by the Owner.

B. Inspections requested by or made necessary as a result of actions of the Contractor on Saturdays, Sundays or holidays must be scheduled and approved in writing by Engineer. The contractor shall bear all additional fees or expenses of Owner's personnel and Inspection services created by extraordinary work hours including standby time or overtime.

1.06 PRE-JOB CONFERENCE

A. A Pre-Job Conference shall be scheduled prior to start of project. The Owner, Contractor and Engineer shall be present. A schedule of work to be accomplished and a list of labor, material and equipment rates for additional work will be established and maintained throughout the project. Contractor shall furnish a complete set of submittal data for use by Engineer.
1.07 QUALITY ASSURANCE

A. Quality assurance procedures and practices shall be used to monitor all phases of surface preparation, application and quality control inspection throughout the duration of the project. Procedures or practices not specifically defined herein may be used provided they meet recognized and acceptable professional standards and are approved by the Engineer.

B. All materials furnished and all work accomplished under the Contract shall be subject to fulltime continuous inspection by the Engineer. The Contractor shall be held strictly to the true intent of the Specifications in regard to quality of materials, workmanship, and diligent execution of the Contract.

C. Work accomplished in the absence of prescribed inspection may be required to be removed and replaced under the proper inspection. The entire cost of removal and replacement, including the cost of all materials which may be furnished by the Owner and used in the work thus removed, shall be borne by the Contractor regardless of whether the work removed is found to be defective or not. Work covered up without the authority of the Engineer, shall upon order of the Engineer, be uncovered to the extent required. The Contractor shall similarly bear the entire cost of performing all the work and furnishing all the materials necessary for the removal of the covering and its subsequent replacement, as directed and approved by the Engineer.

D. The Engineer will make, or have made, such tests as deemed necessary to assure the work is being accomplished in accordance with the requirements of the Contract. Unless otherwise specified, the cost of such testing will be borne by the Owner. In the event such tests reveal non-compliance with the requirements of the Contract, the Contractor shall bear the cost of such corrective measures deemed necessary by the Engineer, as well as the cost of subsequent retesting. It is understood and agreed the making of tests shall not constitute an acceptance of any portion of the work, nor relieve the Contractor from compliance with the terms of the Contract.

1.08 SAFETY AND HEALTH REQUIREMENTS

A. General: ventilation, electrical grounding, and care in handling coatings, paints, solvents and equipment are important safety precautions during coating and painting projects. Contractor shall conform with safety requirements set forth by regulatory agencies applicable to the construction industry and manufacturer’s printed instructions and appropriate technical bulletins and manuals. The Contractor shall provide and require use of personal protective life saving equipment for all persons working in or about the project site.

B. Access Facilities: all ladders, scaffolding and rigging shall be designed for their intended uses. Ladders and scaffolding shall be erected where requested by Engineer to facilitate
inspected and be moved by the Contractor to locations requested by the Engineer.

C. Ventilation: where ventilation is used to control hazardous exposure, all equipment shall be explosion-proof, of industrial design and shall be approved by the Engineer. Ventilation shall reduce the concentration of air contaminant to the degree a hazard does not exist by educting air, vapors, etc. from the confined space. Air circulation and exhausting of solvent vapors shall be continued until coatings have fully cured. Forced air eduction during blast cleaning and coating application operations is mandatory 24 hours per day until coatings have fully cured. If dehumidification equipment is used, equipment must be operated on a continuous basis during all blasting and coating operations, including shifts during which no work is being accomplished. Only ventilation, not dehumidification is required during final curing phases.

1. Ventilation system shall be furnished and installed by the Contractor in accordance with these specifications. The Contractor shall make modifications to the ventilation system as directed by the Engineer to insure a safe working environment and complete removal of all solvent vapors. Upon completion of the final curing period, as determined by the Engineer, the Contractor shall remove the ventilation system.

2. The exhaust blower capacity shall be sufficient to maintain air changes within tank interiors in accordance with OSHA, the coating manufacturer’s recommendations, and the local air quality management district’s regulations.

3. If Contractor uses dehumidification equipment, or any other alternative ventilation systems, Contractor must submit, in advance, for approval by the Engineer, a complete list of equipment and procedures for its use.

4. Where applicable, upon completion of applied coating system, Contractor shall furnish an approved exhaust fan or blower of sufficient capacity to insure removal of solvent vapors during curing process. The fan or blower shall be installed as approved by the Engineer and shall remain in continuous operation until coating is completely cured as determined by the manufacturer of the coating system.

D. Head and Face Protection and Respiratory Devices: equipment shall include protective helmets, which shall be worn by all persons while in the vicinity of the work. During abrasive blasting operations, nozzle-men shall wear U.S. Bureau of Mines approved air-supplied helmets and all other persons who are exposed to blasting dust shall wear approved filter-type respirators and safety goggles. When coatings are applied in confined areas all persons exposed to toxic vapors shall wear approved respiratory protection.

E. Grounding: blasting, spray, and air hoses shall be grounded to prevent accumulation of charges of static electricity.
F. Illumination: spark proof artificial lighting shall be provided for all work in confined spaces. Light bulbs shall be guarded to prevent breakage. Lighting fixtures and flexible cords shall comply with the requirements of NFPA 70 "National Electric Code" for the atmosphere in which they will be used. Whenever required by the Engineer, the Contractor shall provide additional illumination per SSPC Guide 12 and necessary supports to cover all areas to be inspected. The Engineer shall determine the level of illumination required for inspection.

G. Toxicity and Explosiveness: the solvents used with specified protective coatings are explosive at low concentrations and are highly toxic. The maximum allowable concentration of vapor shall be kept below the maximum safe concentration for eight-hour exposure, plus Lower Explosive Limit must be strictly adhered to. If coatings or paints contain lead or other hazardous materials, all regulations related to safety of personnel and handling of such materials shall be strictly adhered to.

H. Protective Clothing: coating and paint materials may be irritating to the skin and eyes. When handling and mixing coatings and paints workmen shall wear appropriate covering gloves and eye shields.

I. Fire: during mixing and application of coatings and paints, all flames, welding and smoking shall be prohibited in the vicinity. Appropriate type fire extinguishers shall be provided by Contractor and kept at the jobsite during all operations.

J. Sound Levels: whenever the occupational noise exposure exceeds the maximum allowable sound levels, the Contractor shall provide and require the use of approved ear protective devices. General sound levels for project shall be those that will not affect routine facility or neighborhood activities. Whenever any levels are objectionable, they shall be adjusted as directed by the Engineer. Adjustments to noise levels required may include the relocation of equipment or the installation of a sound barrier, as required by the Engineer.

K. Compliance with California Code of Regulations: Contractor shall submit a notarized letter signed by a principal officer of the Corporation certifying the Contractor fully complies with California Code of Regulations pertaining to the work including, but not limited to, the following:

1. Illness Injury Prevention Program CSO/GISO 1508/3203
2. Confined Space Plan GISO 5156/5159
3. Respiratory CSO/GISO 1531/5144
4. Hazard Communication GISO 5194
5. Rolling Scaffolds CSO 1646
6. Employee Safety Instruction CSO 1510
7. Emergency Medical Service CSO 5112
8. Dusts, Fumes, Mists, Vapors & Gases CSO 1528
L. Protective Coverings, Containment, and Ventilation Materials/Equipment: The Contractor shall provide all protective coverings needed to protect those surfaces that are not designated to be prepared or coated. Provide all materials needed for the implementation of a containment/ventilation system around the operation to control emissions and exposures in accordance with the provisions of this Section. This includes, but is not limited to, rigging, scaffolding, planking, tarpaulins, dust collectors and vacuums. Verify that all materials are free of lead, chromium, loose dust and debris when brought onto the Owner’s property and upon removal from the site.

1.09 REFERENCE SPECIFICATIONS AND STANDARDS

A. Without limiting the generality of other requirements of these Specifications, all cleaning, surface preparation, and coating work shall conform to the applicable requirements of the referenced portions of the standards specified herein to the extent that the requirements therein specified are not in conflict with the provisions of this Section.

B. Unless otherwise specified, all work and materials for the preparation and coating of all metal surfaces shall conform to the applicable requirements specified in the Steel Structures Painting Manual, Volume 2, Systems and Specifications, latest edition, published by SSPC: The Society for Protective Coatings.

C. The Engineer's decision shall be final as to interpretation and/or conflict between any of the referenced codes, laws, ordinances, specifications and standards contained herein.

D. The latest edition of standards and regulations herein form a part of this specification.

E. American Society for Testing and Materials (ASTM)

1. ASTM E337, Standard Test Method for Measuring Humidity with a Psychrometer

2. ASTM D1186, Standard Test Method for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base

3. ASTM D2240, Standard Test Method for Rubber Property-Durometer Hardness


6. ASTM D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
7. ASTM D4285, Standard Test Method for Indicating Oil or Water in Compressed Air
8. ASTM D4414, Standard Practice for Measurement of Wet Film Thickness by Notch Gages
9. ASTM D4417, Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
11. ASTM D4562, Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces

F. International Concrete Repair Institute (ICRI)

1. Guideline No. 03732, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays.

2. ICRI, Concrete Surface Profile Standards

G. NACE International (NACE)

1. NACE SP 0188-06, Standard Recommended Practice for Discontinuity (Holiday) Testing of Protective Coatings

2. NACE SP 0178-89, Standard Recommended Practice for Fabrication Details, Surface Finish Requirements, and Proper Design Considerations for Tanks and Vessels to be Lined for Immersion Service.
H. Painting Decorators and Contractors of America (PDCA)
   1. PDCA P2 - Third Party Inspections: Qualifications, Responsibilities, and Procedures
   2. PDCA P4 - Responsibility for Inspection and Acceptance of Surfaces Prior to Painting and Decorating
   3. PDCA P13 - The Inspection and Acceptance of Architectural Paints on the Interior Surfaces of Structures When Dry Film Thickness is Specified
   4. PDCA P22 - Cleaning Surfaces Using Pressurized Water

I. SSPC: The Society for Protective Coatings (SSPC)
   1. SSPC-SP5 White Metal Blast Cleaning, removal of all visible rust, mill scale, paint, and foreign matter by blast cleaning by wheel or nozzle (dry) using sand, grit, or shot (Typically for very corrosive atmosphere).
   2. SSPC-SP10 Near-White Blast Cleaning, blast cleaning until at least 95 percent of each element of surface area is free of all visible residues. (For high humidity, chemical atmosphere, marine or other corrosive environment.)
   3. SSPC-SP6 Commercial Blast, blast cleaning until at least 66 percent of each element of surface area is free of all visible residues.
   4. SSPC-SP7 Brush-Off Blast Cleaning, blast cleaning to remove loose rust, loose mill scale, and other detrimental foreign matter present to the degree specified. Loose materials are those that can be removed with a dull putty knife.
   5. SSPC-SP 2/3 Hand/Power Tool Cleaning, hand or powertool cleaning of all loose materials. Loose materials are those that can be removed with a dull putty knife.
   6. SSPC-SP1 Solvent Cleaning, removal of oil, grease, dirt, soil, visible salts, and contaminants by cleaning with solvent, vapor, alkali, emulsion or steam.
   7. Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating (SSPC-SP12)
   8. Surface Preparation of Concrete (SSPC-SP13)
   9. SSPC-PA1, Shop, Field, and Maintenance Painting of Steel
   10. SSPC-PA 2, Measurement of Dry Film Thickness with Magnetic Gages
11. **SSPC-VIS 1**, Visual Standard for Abrasive Blast Cleaned Steel

12. **SSPC-VIS 2**, Standard Method of Evaluating Degree of Rusting on Painted Steel Surfaces


15. **SSPC Publication No. 91-12**, Coating and Lining Inspection Manual

16. **SSPC-SSPC Visual Comparison Manual**

J. Equipment and Coating Manufacturers' Published Instructions.

### 1.10 COMPLIANCE WITH ENVIRONMENTAL REGULATORY REQUIREMENTS

A. Contractor shall comply with all current federal, state, and local environmental laws and regulations, including, but not limited to the laws and regulations of the U.S. Environmental Protection Agency (USEPA), the California Air Resources Board (CARB), and the South Coast Air Quality Management District (SCAQMD).

### 1.11 SUBMITTALS

A. For compliance with these Specifications, the Contractor shall prepare and submit three (3) paint and protective coating samples of each finish, including all coats thereof, to the Owner for review, as specified. The samples shall be clearly marked with the manufacturer's name and product identification, and shall be submitted in sufficient time to allow for review, and, if necessary, resubmittal without causing any delay of the Project.

B. **Coating Materials List**

1. The Contractor shall provide eight (8) copies of a paint and coating materials list which indicates the manufacturer and paint number, keyed to the coating schedule herein, for approval of the Owner prior to, or at the time of, submittal of samples required herein.
2. The Contractor shall include with his submittal his protective coating schedule for shop and field coatings of items to receive protection. The schedule shall conform to the specified requirements for surface preparation, priming, and coating for items covered, and shall follow the same requirements for similar work where such work has not been specifically called-out. No bare ferrous nonworking surfaces shall be omitted from the schedule. Particular care shall be taken to cover in sufficient detail the coating of mechanical joints and other mechanical devices, which shall conform to the recommended practice of the manufacturer of the joint or other mechanical devices.

3. Submittals shall be sufficiently early to permit Owner's review and then Contractor's coordination with affected material and equipment suppliers to assure their use of reviewed shop coats of same manufacture as field coats and compatibility with field applied coats for respective coating system.

4. The coating system shall include a letter from the paint or coating manufacturer endorsing the use of the submitted system for the service environment.

5. Coatings to be used on plastic and fiberglass materials shall be certified as acceptable by all plastic and fiberglass manufacturers whose products are to be coated. Certification copies shall be submitted to the Owner. The Contractor shall be certified in writing by the painting and coating material manufacturers as qualified applicators of their products, and copies of the certification submitted to the Owner.

C. Contractor shall submit paint and coatings material manufacturers' printed Product Data Sheets for materials intended for use in each of various paint and coating systems. Data sheets shall fully describe material as to its intended use, make-up, recommended surface preparation and application conditions, primers, material mixing and application (including recommended dry mil thickness), thinners, precautions, safety and maintenance cleaning directions.

1.12 PROTECTION OF WORK

A. The Contractor shall be responsible for any and all damage to his work or the work of others during the time his work is in progress. The Contractor shall conduct all operations so as to confine general debris, abrasive blasting debris, and paint overspray to within the bounds of the site. The Contractor shall take all precautions necessary to prevent adverse consequences of painting operations. Any complaints received by the Owner relating to any such potential problems will be immediately delivered to the Contractor. The Contractor shall immediately halt work and shall take whatever corrective action is required to mitigate any such problems. All costs associated with protection of off-site properties and/or correction of damage to property as a result of painting operations shall be borne directly by the Contractor at no additional expense to the Owner.
PART 2 - PRODUCTS

2.01 GENERAL

A. Surfaces to receive paint and protective coating materials as herein specified in this Section shall be coated in conformance with the applicable coating systems specified herein. All materials specified by name and/or manufacturer or selected for use under these Specifications shall be delivered unopened at the job site in their original containers and shall not be opened until inspected by the Owner. Whenever a manufacturer's brand name is specified, it is intended to define the general type and quality of paint or coating desired. Other coatings or paints of equal quality may be used, under the approval of the Engineer.

B. Coating materials shall be as specified herein or approved equal. Architectural paint finishes are specified hereinafter. All paint and coatings shall be produced and applied as herein called for, or, if not specifically called for, it shall be applied in accordance with the manufacturer's printed recommendations as reviewed by Owner. So far as possible, all paint and coating materials shall be provided by a single source supplier.

C. Materials specified are those which have been evaluated for the specific service. Products are listed to establish a standard of quality. Standard products of manufacturers other than those specified will be accepted when proven to the satisfaction of the Engineer they are equal in composition, durability, usefulness and convenience for the purpose intended. Substitutions will be considered provided the following minimum conditions are met:

1. The proposed coating or paint system shall have a dry film thickness equal to or greater than that of the specified system.

2. The proposed coating or paint system shall employ an equal or greater number of separate coats.

3. The proposed coating or paint system shall employ coatings or paints of the same generic type.

4. All requests for substitution shall carry full descriptive literature and directions for application, along with complete information on generic type, non-volatile content by volume and a list of 10 similar projects, all at least three years old, where the coatings or paints have been applied to similar exposure. Substitutions shall be endorsed in writing from the materials manufacturer that these substituted materials will provide equivalent performance as those specified.

5. If the above mentioned data appears to be in order, the Engineer may require that the Contractor provide certified laboratory data sheets showing the results
of complete spectrographic and durability tests accomplished on the proposed substitute. An independent testing laboratory satisfactory to the Engineer shall accomplish tests and all costs incurred in the testing program shall be borne by the Contractor. In any case, the Engineer shall be sole and final judge of the acceptability of any proposed substitution. Requests for substitution must be approved in writing.

D. Flammability, toxicity, allergenic properties, and any other characteristic requiring field precautions shall be identified and specific safety practices shall be stipulated.

E. All paint and coating materials shall be stored in enclosed structures to protect them from weather and excessive heat or cold. Flammable coatings and paints must be stored to conform to local, county, state and federal safety codes for flammable coating and paint materials. At all time the paint and coatings shall be protected from freezing.

2.02 PAINT AND COATING MATERIALS

A. Paint and protective coating materials shall be sealed in containers that plainly show the designated name, formula or specification number, batch number, color, date of manufacture, manufacturer's directions, and name of manufacturer, all of which shall be plainly legible at the time of use. Pigmented paints shall be furnished in containers not larger than five (5) gallons.

B. Materials shall conform to the specifications shown herein and to the requirements hereinafter specified. Containers shall not be opened or used until Engineer has physically inspected contents and obtained necessary data from information printed on containers or labels. Materials exceeding storage life recommended by the manufacturer shall be rejected.

C. Products shall be standard for recognized manufacturer engaged in production of such materials for essentially identical or similar applications in the water and wastewater treatment industry and industrial plants.

D. Only compatible materials shall be used in the Work. Particular attention shall be directed to compatibility of primers and finish coats. If necessary, subject to review of the Owner, a compatible barrier coat shall be applied between all existing prime coats and subsequent field coats to ensure compatibility.

E. All colors and shades of colors of all coats of paints and protective coating material shall be as selected by the Owner. Each coat shall be of a slightly different color to facilitate inspection of surface coverage of each coat.
F. Any discrepancies between the coating supplier's written recommendations and the specified requirements herein shall be brought to the attention of the Owner prior to application.

2.03 SERVICE CONDITION A

A. Ferrous metals, other than stainless steel, submerged or intermittently submerged in water, sludge, sewage, chemical mixtures or similar corrosive liquid and all steel angles in contact with concrete shall be prepared and coated in accordance with the following requirements.

B. Surface Preparation. All metal surfaces shall be field abrasive blast cleaned in accordance with SSPC-SP10, Near White Blast Cleaning. A sharp jagged anchor profile of not less than 2 mils, as determined by a Test-Ex Tape Replica Tape, shall be attained. Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed in accordance with NACE SP0178.

C. Application. Application shall be in strict conformance with the manufacturer's printed recommendations. All sharp edges, nuts, bolts, or other items difficult to coat shall receive a stripe coated with a brush-applied coat of the specified coating prior to application of each coat.

D. Coating System A. Except as otherwise noted, the prime coat shall have minimum dry film thickness of 10 mils; and the final coat, 10 mils. The total system shall have a minimum dry film thickness of 20 mils.

   Carboline System: Primer - Carboguard 891 VOC  
                    Final - Carboguard 891 VOC

   Sherwin Williams System: Primer - Sherglass FF Low VOC  
                            Final - Sherglass FF Low VOC

   Tnemec System: Primer - L69 Hi-Build Epoxoline II  
                 Final - L69 Hi-Build Epoxoline II

2.04 SERVICE CONDITION B

A. Ferrous metals, other than stainless steel, not subject to chemical attack, normal indoor or outdoor exposure, shall be prepared and coated in accordance with the following requirements.
B. **Surface Preparation.** All surfaces shall be free of dirt, dust, grease, or other foreign matter that may act as a contaminant. Surfaces, except galvanized, shall be cleaned in accordance with the Steel Structures Painting Council Specification SSPC-SP7 (Brush-Off Blast Cleaning). Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed in accordance with NACE SP0178.

C. **Application.** Application shall be in strict conformance with the manufacturer's printed recommendations. All sharp edges, nuts, bolts, or other items difficult to coat shall receive a brush-applied coat of the specified coating prior to application of each coat.

D. **Coating System B.** Except as specified below, the prime coat shall have a minimum thickness of 1.5 mils and two or more finish coats minimum total dry film thickness of 4.5 mils. The total system shall have a minimum of 6.0 mils.

- **Carboline System:** Primer – Carbocrylic 3358 MC  
  2 Finish Coats – Carbocrylic 3359 MC

- **Sherwin Williams System:** Primer – Procryl Universal Primer  
  2 Finish Coats – Pro Industrial Acrylic

- **Tnemec System:** Primer - Series 115 Uni-Bond DF  
  2 Finish Coats - Tnemec - Series 1029 Enduratone

2.05 **SERVICE CONDITION C**

A. Ferrous metals, other than stainless steel, subject to a corrosive atmosphere and condensation shall be prepared and coated in accordance with the following requirements.

B. **Surface Preparation.** All metal surfaces shall be sandblasted in accordance with Steel Structures Painting Council Specification SSPC-SP10 (Near White Metal Blast Cleaning). A sharp, jagged anchor profile of not less than 2 mils as determined by a profile comparator shall be attained. Weld surface, edges and sharp corners shall be ground to a curve and all weld splatter removed.

C. **Application.** Application shall be in strict conformance with the manufacturer's recommendations.

D. **Coating Systems C.** Except as hereinafter specified, the prime coat shall have a minimum dry film thickness of 3.0 mils; the intermediate coat, 4 mils; and the final coat, 2 mils. The total system shall have a minimum dry film thickness of 9.0 mils.
Carboline System: Primer - Carbozinc 11HS (Shop)
Primer - Carbozinc 859 VOC (field)
Intermediate - Carboguard 890 VOC
Finish - Carbothane 133 MC

Sherwin Williams System: Primer – Corothane I Galvapak -100
Intermediate – Macropoxy 646-100
Finish – Hi Solids Polyurethane-100

Tnemec System: Primer - Series 94H2O Tnem Zinc
Intermediate - L69 Hi-Build Expoxoline II
Finish - 750 UVX Hybrid Polyurethane, Semi-Gloss

2.06 SERVICE CONDITION D

A. Concrete which is subject to submerged and intermittent submergence in water, sludge or chemical mixtures, or which is exposed to corrosive atmospheres, shall be prepared and coated in accordance with the following requirements:

B. Surface Preparation.

1. All green concrete surfaces shall be aged for at least 30 days prior to application.

2. Prior to final preparation of the concrete surfaces, the contractor shall thoroughly clean the surfaces to be lined to remove dirt, residue, and other foreign deposits. Surfaces shall be tested by placing droplets of clean water onto sample locations. Satisfactory surfaces will allow water to be easily absorbed or penetrated into the concrete, while contaminated surfaces will result in the water beading. Contaminated surfaces shall be cleaned. Surfaces showing evidence of such contamination shall be cleaned using solutions of caustic soda or trisodium phosphate (TSP). They should be applied with vigorous scrubbing, followed by flushing with fresh water to remove all traces of both the detergent and contaminant and then allowed to thoroughly dry.

3. The contractor shall use either abrasive blasting or high-pressure waterjetting surface preparation methods to remove any loose concrete and produce a clean, contamination-free, sound, roughened surface acceptable to the lining manufacturer. Abrasive blast cleaning shall be completed in accordance with SSPC-SP7 and SSPC-SP13. The actual water pressure required during any water jetting to achieve the proper removal of deteriorated concrete is not known, but it is projected that pressures between 10,000 to 30,000 psi will be required. Any water jetting equipment shall utilize an oscillating tip.
4. No efflorescence, laitance, or deteriorated concrete shall remain following final surface preparation. Only sound concrete shall remain. The remaining sound concrete shall be uniformly gray in color and appearance.

5. The integrity testing of the prepared concrete shall include dragging the dull edge of putty knife along the prepared surfaces. Properly prepared surfaces will leave behind a scratch without substantial substrate removal. Areas where the scraping action leaves behind a groove or indentation shall be further prepared and retested.

6. All surfaces shall have a surface profile or anchor pattern equal to the International Concrete Repair Institute (ICRI) replica coupon recommended by the coating supplier.

7. The pH of the prepared concrete shall range between 7.0 and 9.0. The pH of the prepared surfaces shall be tested by the contractor according to ASTM D4262.

8. If any reinforcing steel is exposed after removing concrete, it shall be thoroughly cleaned by sandblasting to a near-white metal blast condition (SSPC-SP10).

9. The moisture vapor transmission of the area shall be tested in accordance with ASTM D4263. All testing shall be completed by the contractor and witnessed by the Owner.

10. Prior to installing the coating system, the Contractor shall fill all surface areas with depressions deeper than 1/4-inch by filling in with a resurfacing material that is compatible with the coating system selected. The Contractor shall follow the instructions and recommendations of the manufacturer as to application, curing time requirements, depth of repair, and surface preparation procedures. Any resurfacing material shall be properly prepared through scarification prior to the application of any coatings.

11. The Contractor shall not start application until the surface pH, moisture content, and surface temperature are within the recommended limits, and the prepared surfaces have been accepted by the Engineer. Application shall only be performed when the surface temperature is stable or on the decline.

12. Leading Edges/Terminations: If in the opinion of the Engineer the concrete surfaces specified for coating application does not include a well defined beginning or ending anchor (e.g. terminating edge on lined concrete) or a proper anchored transition between concrete and steel substrates, the coating shall be mechanically anchored to a dry, clean saw cut to a minimum depth of 1/4 inch and width of 1/4 inch. This includes any steel appurtenances penetrating concrete surfaces. The coating system shall be applied into the saw cut to full depth.
13. Should cracks be identified after preparation of concrete that require sealing to assure prevention of moisture intrusion or proper continuous lining work, seal all cracks in accordance with the written recommendations of the lining supplier, as approved by the Engineer.

C. **Application.** Application shall be in strict conformance with the manufacturer's printed recommendations. All coats shall be applied within 24 hours of the previous coat and within the written recoat limitations.

D. **Coating System D.** The prime coat shall have a minimum dry film thickness of 6 mils and two finish coats shall have a minimum total dry film thickness of 16 mils. The total system shall have a minimum dry film thickness of 22 mils.

**Sherwin Williams System:**
- Prime – Corobond 100
- Two Finish Coats – Sherglass FF Low VOC

**Tnemec System:**
- Primer - Series 218 MortarClad (surfacer)
- Two Finish Coats - 436 Perma-Shield FR

### 2.07 SERVICE CONDITION E

A. Concrete surface subject to corrosive atmosphere and condensation shall be prepared and coated in accordance with the following requirements.

B. **Surface Preparation.**

1. All concrete surfaces shall be aged for at least 30 days prior to application.

2. Prior to final preparation of the concrete surfaces, the Contractor shall thoroughly clean the surfaces to be lined to remove dirt, residue, and other foreign deposits. Surfaces shall be tested by placing droplets of clean water onto sample locations. Satisfactory surfaces will allow water to be easily absorbed or penetrated into the concrete, while contaminated surfaces will result in the water beading. Contaminated surfaces shall be cleaned. Surfaces showing evidence of such contamination shall be cleaned using solutions of caustic soda or trisodium phosphate (TSP). They should be applied with vigorous scrubbing, followed by flushing with fresh water to remove all traces of both the detergent and contaminant and then allowed to thoroughly dry.

3. The Contractor shall use either abrasive blasting or high-pressure waterjetting surface preparation methods to remove any loose concrete and produce a clean, contamination-free, sound, roughened surface acceptable to the lining manufacturer. Abrasive blast cleaning shall be completed in accordance with SSPC-SP7 and SSPC-SP13. The actual water pressure required during any water
jetting to achieve the proper removal of deteriorated concrete is not known, but it is projected that pressures between 10,000 to 30,000 psi will be required. Any water jetting equipment shall utilize an oscillating tip.

4. No efflorescence, laitance, or deteriorated concrete shall remain following final surface preparation. Only sound concrete shall remain. The remaining sound concrete shall be uniformly gray in color and appearance.

5. The integrity testing of the prepared concrete shall include dragging the dull edge of putty knife along the prepared surfaces. Properly prepared surfaces will leave behind a scratch without substantial substrate removal. Areas where the scraping action leaves behind a groove or indentation shall be further prepared and retested.

6. All surfaces shall have a surface profile or anchor pattern equal to the International Concrete Repair Institute (ICRI) replica coupon recommended by the coating supplier.

7. The pH of the prepared concrete shall range between 7.0 and 9.0. The pH of the prepared surfaces shall be tested by the Contractor according to ASTM D4262.

8. If any reinforcing steel is exposed after removing concrete, it shall be thoroughly cleaned by sandblasting to a near-white metal blast condition (SSPC-SP10).

9. The moisture vapor transmission of the area shall be tested in accordance with ASTM D4263. All testing shall be completed by the Contractor and witnessed by the Owner.

10. Prior to installing the coating system, the Contractor shall fill all surface areas with depressions deeper than 1/4-inch by filling in with a resurfacing material that is compatible with the coating system selected. The Contractor shall follow the instructions and recommendations of the manufacturer as to application, curing time requirements, depth of repair, and surface preparation procedures. Any resurfacing material shall be properly prepared through scarification prior to the application of any coatings.

11. The Contractor shall not start application until the surface pH, moisture content, and surface temperature are within the recommended limits, and the prepared surfaces have been accepted by the Engineer. Application shall only be performed when the surface temperature is stable or on the decline.

12. Leading Edges/Terminations: If in the opinion of the Engineer the concrete surfaces specified for coating application does not include a well defined beginning or ending anchor (e.g. terminating edge on lined concrete) or a proper anchored transition between concrete and steel substrates, the coating shall be mechanically anchored to a dry, clean saw cut to a minimum depth of 1/4 inch
and width of 1/4 inch. This includes any steel appurtenances penetrating concrete surfaces. The coating system shall be applied into the saw cut to full depth.

13. Should cracks be identified after preparation of concrete that require sealing to assure prevention of moisture intrusion or proper continuous lining work, seal all cracks in accordance with the written recommendations of the lining supplier, as approved by the Engineer.

C. **Application.** Application shall be in strict conformance with the manufacturer’s recommendations, including recoat times.

D. **Coating System E.** First and second coats shall have a minimum dry film thickness of 4.0 mils each. The top coat, minimum dry film thickness shall be 1.5 mils. The total system shall have a minimum dry film thickness of 9.5 mils.

- **Carboline System:**
  - First Coat – Semstone 110
  - Second Coat – Carboguard 890 VOC
  - Topcoat – Carbothane 133 MC

- **Sherwin Williams System**
  - First Coat – Macropoxy 646-100
  - Second Coat – Macropoxy 646-100
  - Topcoat – Hi Solids Polyurethane-100

- **Tnemec System:**
  - First Coat - Series 287 Enviro-Pox
  - Second Coat - Series 287 Enviro-Pox
  - Topcoat - Series 297 Enviro-Glaze

- **Lifelast System:**
  - First Coat - Primall 160
  - Second Coat - Durasheild 310

2.08 **SERVICE CONDITION F**

A. Coating for plastic and fiberglass pipe for purposes of color coding and label stenciling. Coatings to be used for this category shall be certified by the pipe manufacturer to be completely acceptable and non-injurious to the pipe.

B. **Surface Preparation.** Lightly sand pipe and wipe with a solvent to degrease and clean surface.

C. **Application.** Application shall be in strict conformance with manufacturer's printed recommendation.

D. **Coating System F.** Two (2) coats having a total dry film thickness of 8.0 mils.
Carboline System:  
Prime Coat - Carbothane 133 MC  
Second Coat - Carbothane 133 MC  

Sherwin Williams System:  
Prime Coat – Macropoxy 646-100  
Finish Coat – Hi Solids Polyurethane-100  

Tnemec System:  
Series 115 Uni-Bond DF  
Series 1029 Endurotone  

2.09 SERVICE CONDITION G  

A. Submerged moving parts including cables, chains, gears, pulleys, etc. shall be prepared and coated in accordance with the following requirements.  

B. Surface Preparation. All rust, scale, dust, and foreign matter removed by power or hand tool cleaning.  

C. Application. Application shall be in strict accordance with manufacturer's recommendation.  

D. Coating System G. The system shall have a total thickness of 25 mils and shall consist of the following:  

   Chevron - E.P. Roller Grease  
   Texaco - Rust Inhibitive Grease  

2.10 SERVICE CONDITION H  

A. Ferrous metals requiring a heat resistant coating. To ensure proper coating selection, accurately measure surface temperatures. Surface preparation shall be performed in strict conformance with manufacturer’s printed directions and treated surfaces shall be coated as soon as possible to avoid surface contamination. In conformance with printed directions of manufacturer: mix and apply coats of each system; and cure coats before recoating or before reaching surface operating temperature. Contingent upon expected temperature range, apply one of the following or equal systems, and avoid excessive film thickness.  

B. Coating System H apply high-temperature coating in strict accordance with the manufacturer recommendations. Some systems may exceed VOC limit restrictions for SCAQMD Rule 1113 and will require installation in a jurisdiction with higher VOC limits.
Rust-Oleum Systems:

300-800° F Temp. Range 4200 System
400-1200° F Temp. Range 4300 System

Carboline Systems:

Up to 450° F Temp. Thermaline 2977 VOC / Thermaline 4900 VOC
400-1200° F Temp. Carbozinc 11 Series / Thermaline 4700 VOC

Sherwin Williams Systems:

Ambient To 250° F: Prime – Corothane I Galvapak -100
            Finish – Pro Industrial Acrylic
To 500°F:  Prime - Heat-Flex Hi Temp 1200
            Finish – Heat-Flex Hi Temp 500
500°F to 1200°F: Prime - Heat-Flex Hi Temp 1200
            Finish – Heat-Flex Hi Temp 1100

2.11 SERVICE CONDITION I

A. Coating of concrete and metal surfaces within the extremely corrosive areas as indicated on the Schedule.

B. Surface Preparation - Concrete.

1. All concrete surfaces shall be aged for at least 30 days prior to application.

2. Prior to final preparation of the concrete surfaces, the Contractor shall thoroughly clean the surfaces to be lined to remove dirt, residue, and other foreign deposits. Surfaces shall be tested by placing droplets of clean water onto sample locations. Satisfactory surfaces will allow water to be easily absorbed or penetrated into the concrete, while contaminated surfaces will result in the water beading. Contaminated surfaces shall be cleaned. Surfaces showing evidence of such contamination shall be cleaned using solutions of caustic soda or trisodium phosphate (TSP). They should be applied with vigorous scrubbing, followed by flushing with fresh water to remove all traces of both the detergent and contaminant and then allowed to thoroughly dry.
3. The Contractor shall use either abrasive blasting or high-pressure waterjetting surface preparation methods to remove any loose concrete and produce a clean, contamination-free, sound, roughened surface acceptable to the lining manufacturer. Abrasive blast cleaning shall be completed in accordance with SSPC-SP7 and SSPC-SP13. The actual water pressure required during any water jetting to achieve the proper removal of deteriorated concrete is not known, but it is projected that pressures between 10,000 to 30,000 psi will be required. Any water jetting equipment shall utilize an oscillating tip.

4. No efflorescence, laitance, or deteriorated concrete shall remain following final surface preparation. Only sound concrete shall remain. The remaining sound concrete shall be uniformly gray in color and appearance.

5. The integrity testing of the prepared concrete shall include dragging the dull edge of putty knife along the prepared surfaces. Properly prepared surfaces will leave behind a scratch without substantial substrate removal. Areas where the scraping action leaves behind a groove or indentation shall be further prepared and retested.

6. All surfaces shall have a surface profile or anchor pattern equal to the International Concrete Repair Institute (ICRI) replica coupon recommended by the coating supplier.

7. The pH of the prepared concrete shall range between 7.0 and 9.0. The pH of the prepared surfaces shall be tested by the Contractor according to ASTM D4262.

8. If any reinforcing steel is exposed after removing concrete, it shall be thoroughly cleaned by sandblasting to a near-white metal blast condition (SSPC-SP10).

9. The moisture vapor transmission of the area shall be tested in accordance with ASTM D4263. All testing shall be completed by the Contractor and witnessed by the Owner.

10. Prior to installing the coating system, the Contractor shall fill all surface areas with depressions deeper than 1/4-inch by filling in with a resurfacing material that is compatible with the coating system selected. The Contractor shall follow the instructions and recommendations of the manufacturer as to application, curing time requirements, depth of repair, and surface preparation procedures. Any resurfacing material shall be properly prepared through scarification prior to the application of any coatings.

11. The Contractor shall not start application until the surface pH, moisture content, and surface temperature are within the recommended limits, and the prepared surfaces have been accepted by the Engineer. Application shall only be performed when the surface temperature is stable or on the decline.
12. Leading Edges/Terminations: If in the opinion of the Engineer the concrete surfaces specified for coating application does not include a well defined beginning or ending anchor (e.g. terminating edge on lined concrete) or a proper anchored transition between concrete and steel substrates, the coating shall be mechanically anchored to a dry, clean saw cut to a minimum depth of 1/4 inch and width of 1/4 inch. This includes any steel appurtenances penetrating concrete surfaces. The coating system shall be applied into the saw cut to full depth.

13. Should cracks be identified after preparation of concrete that require sealing to assure prevention of moisture intrusion or proper continuous lining work, seal all cracks in accordance with the written recommendations of the lining supplier, as approved by the Engineer.

C. Surface Preparation - Steel.

1. All metal surfaces shall be field abrasive blast cleaned in accordance with SSPC-SP10, Near White Blast Cleaning. A sharp, jagged anchor profile not less than 3.5 mils shall be attained. Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed in accordance with NACE SP0178.

D. Application. Application shall be in strict conformance with the manufacturer’s printed recommendations. The applicator shall be a licensed applicator by the coating manufacturer. The finished coating shall be spark tested and all holidays repaired in accordance with NACE SP0188.

E. Coating System I. Except as otherwise noted, the prime coat on metal surfaces shall have a minimum thickness of 2.0 mils and a maximum thickness of 3.0 mils. The finish coat on a non-abrasive metal surface shall be 30 mils and in an abrasive area shall be 40 mils. The prime coat on concrete surfaces shall have a minimum thickness of 3.0 mils and a maximum thickness of 5.0 mils. The finish coat shall be a minimum 65 mils dry film thickness.

Carboline System: Primer - Plasite 4503  
Topcoat - Reacatamine 760 Series

Sherwin Williams System: Concrete Primer - Corobond 300  
Steel Primer – Macropoxy 646-100  
Finish Coat – Sherflex Elastomeric Polyurethane

Sancon System: Concrete Primer - Sancon 100 Epoxy  
Steel Primer - United 302 Urethane  
Topcoat - Sancon 100 Polyurethane

Lifelast System: Concrete Primer - Primall 160  
Topcoat - Durachield 310
2.12 ARCHITECTURAL PAINT FINISHES

A. Manufacturer. Unless otherwise noted, products listed below are the standards of quality. Other materials may be approved if they meet the requirements of Section 2.01.

1. System P–1 - Enamel on Structural Steel Members

**Frazee Paint System:**
- First Coat - C309 UltraTech Water-Based Universal Metal Primer (Delete on factory primed materials)
- Second Coat - 136 Aro-Thane Water-Based Urethane Modified Alkyd Semi-Gloss
- Third Coat - 136 Aro-Thane Water-Based Urethane Modified Alkyd Semi-Gloss

**Sherwin Williams System:**
- First Coat – Procryl Universal Primer (Delete on factory or shop primed materials)
- Second Coat – Procryl Universal Primer
- Third Coat – Pro Industrial Acrylic
- Fourth Coat – Pro Industrial Acrylic

**Vista Paint System:**
- First Coat - Vista 9600 Protec Primer (Delete on factory primed materials)
- Second Coat - Vista 9800 Protec Semi-Gloss Enamel
- Third Coat - Vista 9800 Protec Semi-Gloss Enamel

**Dunn Edwards System:**
- First Coat - BLOC-RUST Premium Red Rust Preventative Primer (BRPR00-1-RO) (delete on factory primed materials)
- Second Coat – Ultrasheild – Gloss ULSH60
- Third Coat – Ultrasheild Gloss ULSH60
- Fourth Coat – not necessary
2. **System P-2 - Concrete Masonry Paint on Concrete Unit Masonry**

   **Frazee Paint System:**
   
   First Coat - C251 Flex Lox Epoxy-Acrylic High pH Masonry Primer
   
   Second Coat - 146 Aro-Thane Water Based Urethane Mod. Alkyd Gloss
   
   Second Coat - 146 Aro-Thane Water Based Urethane Mod. Alkyd Gloss

   **Sherwin Williams System:**
   
   Monochem System:
   
   First Coat – Aquaseal ME12
   
   Second Coat – Permasheeld Premium
   
   Third Coat – Permasheeld Premium

   **Vista Paint System:**
   
   First Coat - Vista 4600 Uniprime II Masonry Primer
   
   Second Coat- Vista 290 Uretech Acrylic Gloss Urethane
   
   Third Coat - Vista 290 Uretech Acrylic Gloss Urethane

   **Dunn Edwards System:**
   
   First coat – Carboline – Sanitile 100 (If on concrete block)
   First coat – Carboline – Sanitile 120 (If not on block)
   
   Second coat – Carboline, Carbothane 134
   
   Third coat – Carboline, Carbothane 134

3. **System P-3 - Concrete Masonry Paint on Concrete**

   **Frazee Paint System:**
   
   First Coat - 203 Duratec II Exterior 100% Acrylic Flat
   
   Second Coat - 203 Duratec II Exterior 100% Acrylic Flat
Sherwin Williams System:  
First Coat – Loxon Concrete Masonry Primer  
Second Coat – Loxon Acrylic Coating

Vista Paint System:  
First Coat - Vista 4600 Uniprime II Masonry Primer  
Second Coat- Vista 2000 Duratone 100% Acrylic Flat  
Third Coat - Vista 2000 Duratone 100% Acrylic Flat

Dunn Edwards System:  
First coat - Eff Stop Premium Primer (ESPR00)  
Second Coat - Evershield 100% Acrylic (EVSH10)  
Third Coat - Evershield 100% Acrylic (EVSH10)

4. **System P-4 - Enamel on Galvanized Metal** (Doors, Frames, & Sheet Metal)  
Frazee Paint System:  
Pretreatment - Krud Kutter Metal Clean and Etch  
First Coat - C309 UltraTech Water-Based Universal Primer  
Second Coat - 136 Aro-Thane Water-Based Urethane Modified Alkyd Semi-Gloss  
Third Coat - 136 Aro-Thane Water-Based Urethane Modified Alkyd Semi-Gloss

Sherwin Williams System:  
Pretreatment – Great Lakes Clean and Etch  
First Coat– Procryl Universal Primer  
Second Coat - Pro Industrial Acrylic  
Third Coat – Pro Industrial Acrylic

Vista Paint System:  
Pretreatment - Jasco Prep N Prime  
First Coat - Vista 4800 Acrylic Metal Prime
Second Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

Third Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

Dunn Edwards System: Pretreatment – Carboline – Galoseal (if substrate is unpainted galvanized)

First Coat – If previously painted use Ultrashield DTM Gray Primer ULDM00GR

Second Coat - Ultrashield Gloss ULSH60

Third Coat - Ultrashield Gloss ULSH60

5. **System P-5 - Enamel on Primed Metal**

   Frazee Paint System: First Coat - 168 Prime+Plus Primer/Sealer

   Second Coat - 136 Aro-Thane Water-Based Urethane Modified Alkyd Semi-Gloss

   Sherwin Williams System: Prime Repair Coat - Procryl Universal Primer

   First Coat – Pro Industrial Acrylic

   Second Coat - Pro Industrial Acrylic

   Vista Paint System: First Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

   Second Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

   Dunn Edwards System: First Coat – Ultrashield Multi Surface Primer ULMS

   Second Coat - Ultrashield Gloss ULSH60
6. **System P-6 - Semi Gloss Enamel Paint on Interior Concrete Unit Masonry**

   - **Frazee Paint System:**
     - First Coat - C302 Ultra Tech 100% Acrylic Block Filler
     - Second Coat - 124 Mirro Glide 100% Acrylic Semi-Gloss
     - Second Coat - 124 Mirro Glide 100% Acrylic Semi-Gloss

   - **Sherwin Williams System:**
     - First Coat – Loxon Block Resurfacer
     - Second Coat – Pro Industrial Acrylic
     - First Coat - Pro Industrial Acrylic

   - **Vista Paint System:**
     - First Coat - Vista 040 Block Coat
     - Second Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel
     - Third Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

   - **Dunn Edwards System:**
     - First Coat - "Blocfill" Smooth W305SMOOTH BLOCFILL (SBPR00)
     - Second Coat - Decoglo W450SUPREMA (SPMA50)
     - Third Coat - Decoglo W450SUPREMA (SPMA50)

7. **System P-7 - Sealer for Unpainted Masonry Surfaces**

   A transparent waterproofing sealer shall be applied to all above grade masonry surfaces, with the exception of interior building walls, both smooth face and split face block as shown on plans and in Coating Systems Schedule. Apply to dry, clean split faced surface with airless spray. Rate of application shall be in accordance with manufacturer’s recommendations.

   - **Frazee Paint System:**
     - Monochem 4990 Aquaseal SS Water Repellent
Vista Paint System: Monochem Aquaseal ME12
Dunn Edwards System: Rainguard - Microseal

8. **System P-8 - Interior Pipe Insulation**

Frazee Paint System:
- First Coat - C152 Ultratech Multi-Solution Latex Primer
- Second Coat - 077 Velvin ETU Latex Flat

Vista Paint System:
- First Coat - Vista 8000 PrimeZall
- Second Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel
- Third Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

Dunn Edwards System:
- First Coat - Sanitile 120
- Second Coat - Ultrashield Gloss ULSH60

9. **System P-9 - Metal Protected Exterior Pipe Insulation**

Frazee Paint System:
- First Coat - C309 Ultratech Water Based Universal Primer
- Second Coat - 203 Duratech II Exterior 100 Acrylic Flat

Vista Paint System:
- First Coat - Vista 9600 Protec Primer
- Second Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel
- Third Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

Dunn Edwards System:
- First Coat - Ultrashield DTM Gray Primer ULDM00GR
- Second Coat - Ultrashield Gloss ULSH60
10. **System P-10 - New Galvanized Surfaces**

   **Frazee Paint System:**  
   Pretreatment - Krud Kutter Metal Clean and Etch  
   First Coat - C309 UltraTech Water-Based Universal Primer  
   Second Coat - 136 Aro-Thane Water-Based Urethane Modified Alkyd Semi-Gloss  
   Third Coat - 136 Aro-Thane Water-Based Urethane Modified Alkyd Semi-Gloss  

   **Vista Paint System:**  
   Pretreatment - Jasco Prep N Prime  
   First Coat - Vista 4800 Acrylic Metal Prime  
   Second Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel  
   Third Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel  

   **Dunn Edwards System:**  
   Pretreatment – Carboline – Galoseal (if substrate is unpainted galvanized)  
   Prime Coat – If previously painted use Ultrashield DTM Gray Primer ULM00GR  
   Second Coat - Ultrashield Gloss ULSH60  
   Third Coat - Ultrashield Gloss ULSH60

11. **System P-11 - Spot Repair of Damaged New Galvanized Metal**

   **Frazee Paint System:**  
   First Coat - C309 UltraTech Water-Based Universal Primer  
   Second Coat - 136 Aro-Thane Water-Based Urethane Modified Alkyd Semi-Gloss  

   **Vista Paint System:**  
   First Coat - Vista 4800 Acrylic Metal Prime  
   Second Coat - Vista 8400 Carefree 100%
### Part 3: Execution

#### 3.01 General

A. All surface preparation, coating and paint application shall conform to applicable standards of SSPC and the manufacturer's printed instructions. Material applied prior to approval of the surface by the Engineer shall be removed and reapplied to the satisfaction of the Engineer at the expense of the Contractor.
B. All work shall be performed by skilled craftsmen qualified to accomplish the required work in a manner comparable with the best standards of practice. Continuity of personnel shall be maintained and transfer of key personnel shall be coordinated with the Engineer.

C. The Contractor shall provide a supervisor to be at the work site during cleaning, application operations. The supervisor shall have the authority to sign any change orders, coordinate work and make other decisions pertaining to the fulfillment of their contract.

D. Contractor shall provide approved sanitary facilities for all project personnel, as no existing facilities will be available to the Contractor. Facilities shall be maintained during the project to complete standards established by Owner, and shall be removed prior to Contractor's departure from the site at completion of the project.

E. Dust, dirt, oil, grease or any foreign matter which will affect the adhesion or durability of the finish must be removed by washing with clean rags dipped in an approved commercial cleaning solvent, rinsed with clean water and wiped dry with clean rags.

F. The Contractor's painting and coating equipment shall be designed for application of materials specified and shall be maintained in first class working condition. Compressors shall have suitable traps and filters to remove water and oils from the air. Blotter test shall be accomplished at each start-up period and as deemed necessary by the Engineer. Contractor's equipment shall be subject to approval of the Engineer.

1. Cleanliness of compressed air supply used for conventional equipment or blow down operations shall be verified daily, and as deemed necessary by Engineer, by directing a stream of air, without abrasive, from the blast nozzle onto a white blotter or cloth for twenty seconds in accordance with ASTM D4285. If air contamination is evident, change filters, clean traps, add moisture separators or filters, or make adjustments as necessary to achieve clean, dry air.

G. Application of the first coat shall follow immediately after surface preparation and cleaning within an eight-hour working day. Any cleaned areas not receiving first coat within an eight-hour period shall be recleaned prior to application of first coat.

H. Because of the presence of moisture and possible contaminants in the working atmosphere, care shall be taken to ensure previously coated or painted surfaces are protected or recleaned prior to application of subsequent coat(s). The Engineer shall approve methods of protection and recleaning.

1. The project is subject to intermittent shutdown if, in the opinion of the Engineer, cleaning, coating and painting operations are creating a localized condition
detrimental to ongoing facility activities, personnel, or adjacent property.

2. In the event of emergency shutdown by the Engineer, Contractor shall immediately correct deficiencies. All additional costs created by shutdown shall be borne by Contractor.

I. The Contractor shall provide, at his own expense, all necessary power for his operations under the contract.

J. Inspection: all operations will be monitored 100% by an Owner-appointed quality assurance inspector. All additional costs incurred by off-site inspection shall be borne by the Contractor. These include, but are not limited to travel, lodging, food, auto rental (where applicable) and any other expenses directly related to the inspection.

3.02 QUALITY CONTROL

A. Ambient Conditions: no coating shall be applied when the surrounding air temperature or the temperature of the surface to be coated or painted is below 50 degrees F. No coatings shall be applied at temperatures above 110 degrees F. No coatings shall be applied to wet or damp surfaces or in rain, snow, fog or mist, when the surface temperature is less than 5 degrees F. above the dewpoint, or when it is expected the air temperature will drop below 50 degrees.

B. Dewpoint shall be measured by the use of an instrument such as a Sling Psychrometer in conjunction with U.S. Department of Commerce Weather Bureau Psychrometric Tables or equivalent in accordance with ASTM D337. Relative humidity shall not be more than 85 percent. If unacceptable conditions are prevalent coating or paint application shall be delayed or postponed until conditions are favorable. The day's coating or paint application shall be completed in time to permit the film sufficient drying time prior to damage though atmospheric conditions. Temperature and dewpoint requirements noted above and herein shall apply to all surface preparation operations, except low and high temperature limits.

C. Surface Preparation: surface preparation will be based upon comparison with: "Pictorial Surface Preparation Standards for Painting Steel Surfaces," SSPC-Vis 1 and as described herein. Anchor profile for prepared steel surfaces shall be sharp and jagged (not peened) and measured by using a nondestructive instrument such as a Testex Press-0-Film System in accordance with ASTM D4417. Anchor profile for prepared concrete shall be measured by using an ICRI CSP comparison coupons.

D. The Contractor shall conduct all operations so as to confine debris and overspray to within the bounds of the site. The Contractor shall take all precautions necessary to prevent adverse off-site consequences of painting operations. Any complaints received
by the Owner relating to any such potential offsite problems will be immediately delivered to the Contractor. The Contractor shall immediately halt work and shall take whatever corrective action is required to mitigate any such problems. All costs associated with protection of off-site properties and/or correction of damage to property as a result of painting operations shall be borne directly by the Contractor at no additional expense to the Owner.

E. Film Thickness Testing: thickness of each coat of coating shall be checked with a non-destructive film thickness gauge in accordance with ASTM D7091, where applicable.

F. Inspection Devices: Contractor shall furnish, until final acceptance of coating and painting, inspection devices in good working condition for hardness, adhesion, detection of holidays, and measurement of dry-film thickness of coatings and paints, where required. They shall also furnish National Institute of Standards and Technology/National Bureau of Standards (NIST/NBS) certified thickness calibration plates to test accuracy of thickness gauges. Acceptable devices for ferrous metal surfaces include, but are not limited to Tinker-Rasor Models M-1, AP, and AP-W holiday detectors and SSPC, Type II units for dry film thickness gauging. Inspection devices shall be calibrated and operated in accordance with specified requirements. High-voltage testing shall require written acceptance from the lining manufacturer. Adhesion shall be measured using a fixed alignment, type II pull-off adhesion tester such as an Elcometer 106. Hardness testers shall be Type Shore D or as recommended by the lining manufacturer.

G. Gauges and detectors shall be available at all times until final acceptance of application. Inspection devices shall be operated by, or in the presence of the Engineer with location and frequency basis determined by the Engineer. The Engineer is not precluded from furnishing his own inspection devices and rendering decisions based solely upon these quality assurance tests. Should in the opinion of the Engineer a 24-hour, continuous reading surface temperature gauge be required to assure that maximum recoat windows are observed, the Contractor shall provide a working calibrated instrument to meet this need. The gauge shall be digital and capable of providing instantaneous average measurements of the temperatures recorded.

3.03 SURFACE PREPARATION, GENERAL - INDUSTRIAL

A. Slag, weld spatter, or sharp edges such as those created by flame cutting shall be removed by chipping and grinding. All sharp edges shall be peened, ground or otherwise blunted as required by the Engineer in accordance with NACE SP 0178. The rolled edges of angles, channels, and wide flange beams do not normally require further rounding unless specifically directed by the Engineer.

B. Abrasive blasting nozzles shall be equipped with "deadman" emergency shut-off nozzles. Blast nozzle pressure shall be a minimum of 95 P.S.I. and shall be verified by using an approved nozzle pressure gage at each start-up period or as directed by the Engineer.
Number of nozzles used during all blast cleaning operations must be sufficient to insure timely completion of project as approved and directed by Engineer.

C. All blast hose connections shall be connected with external couplings. These connections shall be taped with duct tape prior to pressurizing. All taped connections shall be visually inspected for leaks within five minutes after start of blast cleaning operations and at the end of blast cleaning operations. Leaking connections shall be immediately repaired to prevent further damage.

D. Particle size of abrasives used in blast cleaning shall be that which will produce a surface profile or anchor pattern specified herein, or in accordance with recommendations of the manufacturer of the specified coating or paint system to be applied, subject to approval of Engineer. Surface Profile or Anchor pattern shall be sharp and jagged in nature (not peened).

E. Abrasive used in blast cleaning operations shall be new, washed, graded and free of contaminants, which would interfere with adhesion of coatings and paints and shall not be reused unless specifically approved by the Engineer. Abrasives shall be certified for unconfined dry blasting pursuant to the California Administrative Code, Section 92520 of Subchapter 6, title 17, and shall appear on the current listing of approved abrasives.

F. The Contractor shall select an abrasive media that is proper for the quality of surface preparation specified. Should it be determined that the production rate and quality of the surface preparation is less than specified, it shall be the Contractor’s responsibility to use other types and/or sizes of abrasive to meet the requirements of this contract. At no time shall considerations of extra effort be considered by the Owner unless, in the opinion of the Engineer the Contractor has explored all alternative means of abrasive blasting during their operations.

G. Blast cleaning from rolling scaffolds shall only be performed within the confines of the interior perimeter of the scaffold. Reaching beyond the limits of the perimeter will be allowed only if blast nozzle is maintained in a position, which will produce a profile acceptable to the Engineer.

H. The Contractor shall keep the area of work in a clean condition and shall not permit blasting materials to accumulate as to constitute a nuisance or hazard to the prosecution of the work or the operation of the existing facilities. Spent abrasives and other debris shall be removed at the Contractor’s expense as directed by the Engineer. If waste is determined to be hazardous, disposal by Contractor shall meet requirements of all regulatory agencies for handling such wastes.

I. Blast cleaned surfaces shall be cleaned prior to the application of specified coatings or paints through a combination of blowing with clean dry air, brushing/brooming and/or vacuuming as directed by the Engineer. Air hose for blowing shall be at least 1/2" in
diameter and shall be equipped with a shut-off device.

J. The surfaces of any non-carbon steel substrates, or specialty items (i.e. galvanized, anodized, etc.) shall be properly treated and prepared prior to any coating operations in accordance with the coating manufacturer's written recommendations, subject to approval of the Engineer.

3.04 SURFACE PREPARATION, GENERAL - ARCHITECTURAL

A. Before Priming, correct all finish surfaces which are not properly prepared. Assure that all surfaces to be painted are in a proper condition as required by the manufacturer's written recommendations and will provide a proper uniform appearance. Do not prime any surface that has not been approved by the Engineer.

B. Prior to surface preparation and painting operations, remove all hardware, hardware accessories, plates, lighting fixtures and similar items in contact with painted surfaces and not to be painted. Replace all removed items following completion of all paint work in the area. Items may be protected and not removed if approved by the Engineer.

C. Program and schedule cleaning and painting so that dust and other contaminants from the cleaning process will not fall on wet, newly painted surfaces.

D. Clean concrete and masonry surfaces of all dirt, encrustations, efflorescence and other foreign matter. Roughen all glazed surfaces on concrete.

E. Clean ferrous metal not provided with a shop prime of all loose rust, mill scale, oil, grease and foreign matter by wire brushing, scraping or sandblasting as required by the written requirements of the paint manufacturer and SSPC-SP2/3. Clean ferrous metal provided with shop prime of all oil, grease and foreign matter in accordance with SSPC-SP1 and the manufacturer's written requirements.

F. Clean gypsum board (drywall) of all dust, dirt, encrustations and foreign matter.

3.05 APPLICATION, GENERAL

A. Coating and paint application shall conform to the requirements of the SSPC's Paint Application Specification No. 1 (SSPC-PA1), latest revision, for "Shop, Field and Maintenance Painting," the manufacturer of the coating and paint materials printed literature, and as specified herein.

B. All surfaces to receive paint and protective coatings shall be cleaned as specified herein prior to application of coating materials. The Contractor shall examine all surfaces to be coated, and shall correct all surface defects before application of any coating material. Beginning the coating work without reporting unsuitable conditions to the Owner constitutes acceptance of conditions by the Contractor. Any required removal, repair, or
replacement of the work caused by unsuitable conditions shall be done at no additional cost to the Owner. All marred or abraded spots on shop-primed and factory-finished surfaces shall receive touch-up restoration prior to any other coating application.

C. Paint and coating materials shall be protected from exposure to excessive hot or cold weather, and shall be thoroughly stirred, strained, and kept at a uniform consistency during application. Materials of different manufacturers shall not be mixed together. Packaged materials may be thinned immediately prior to application in accordance with the manufacturer’s directions.

D. All coatings shall be thoroughly mixed utilizing an approved slow-speed power mixer until all components are thoroughly combined and are of a smooth consistency.

E. Thinning shall only be permitted as recommended by the manufacturer and approved by the Engineer, and shall not exceed the limits set by applicable regulatory agencies.

1. If the Contractor applies any coatings which have been modified or thinned to such a degree as to cause them to exceed established VOC levels, Contractor shall be responsible for any fines, costs, remedies, or legal action and costs which may result.

F. Each application of coating and paint shall be applied evenly with a uniform appearance. The system shall be free of brush marks, unfeathered edges, sags, runs, and evidence of poor workmanship, or any aesthetic defects, as defined by SSPC. Care should be exercised to avoid lapping on glass or hardware. Coating and paint shall be sharply cut to lines. Finished surfaces shall be uniform in appearance and shall be free from defects or blemishes.

G. Coatings shall not be applied when area wind speeds exceed fifteen miles per hour.

H. Protective coverings or drop cloths shall be used to protect floors, concrete, fixtures, equipment, prepared surface and applied coatings. Personnel entering work area shall take precautions to prevent damage or contamination of coated or painted surfaces. Care shall be exercised to prevent coating or paint from being spattered onto surfaces, which are not to be coated or painted. Surfaces from which such material cannot be removed satisfactorily shall be replaced, repainted or recoated as required to produce a finish satisfactory to the Engineer.

I. All welds and irregular surfaces, as defined by the Engineer shall receive a brush coat of the specified product prior to application of each complete coat. Coating/paint shall be brushed in multiple directions to insure penetration and coverage, as directed by the Engineer.
J. Coating which has endured an excessive time element beyond manufacturer’s recommended recoat cycle, shall be scarified by methods approved by the Engineer, prior to application of additional coating or paint. Scarified coating shall have sufficient depth to assure a mechanical bond of subsequent coat.

K. All attachments, accessories, and appurtenances, as defined by the Engineer, to be painted shall be prepared and finished in the same manner as specified for adjacent sections.

3.06 APPLICATION, SPECIFIC - ARCHITECTURAL

A. Coating shall be thoroughly stirred or agitated to uniformly smooth consistency and prepared and handled in a manner to prevent deterioration and inclusion of foreign matter. Straining shall be completed as recommended by the paint manufacturer. Unless otherwise specified or reviewed, no materials shall be reduced, changed, or used except in accordance with the manufacturer’s label or tag on container.

B. Unless otherwise specified herein, the paint and coating manufacturer’s printed recommendations and instructions for thinning, mixing, handling, applying, and protection of coating materials; for preparation of surfaces for coating; and for all other procedures relative to coating shall be strictly observed. No substitutions or other deviations shall be permitted without written permission of the Owner.

C. Materials shall be delivered in manufacturer’s original, sealed containers, with labels and tags intact. Coating materials and equipment shall be stored in designated areas. Coating containers shall be opened only when required for use. Coatings shall be mixed only in designated rooms or spaces in the presence of the Engineer.

D. Apply material evenly, free from sags, fisheyes, runs, drips, crawls, holidays or other defects. Mix to proper consistency, brush out all areas smooth leaving only minimum brush marks.

1. Sand and dust between each coat to remove defects visible from a distance of five feet.

2. Finish coats shall be uniform in appearance, smooth, free of brush marks, streaks, laps, and skipped or missed areas. Finished metal surfaces shall be free of skips, voids or pinholes in any coat when tested with a low voltage detector.

3. Do not apply initial coating until moisture content of surface is within limitations recommended by paint manufacturer.
4. Rate of application shall not exceed that as recommended by paint manufacturer for the surface involved less ten percent allowance for losses.

5. Keep brushes and spraying equipment clean, dry, free from contaminants and suitable for the finish required.

6. Apply paint by clean brushes, roller or spray. Rollers shall be cleaned of loose nap prior to use.

7. Tint all pigmented undercoats to approximately same shade as final coat. Perceptibly increase the depth of shade in successive coats.

8. Allow each coat to dry thoroughly before succeeding coat application. For oil paints, allow at least 48 hours between coats of exterior work, except where otherwise recommended by the manufacturer.

9. Finish all four edges of doors with the same number and kind of coatings as specified for their main surfaces. Where openings into rooms having different finishes, finish door edges as directed by Engineer.

10. Do not paint factory finished items unless specifically directed.

11. Paint surfaces of metal ducts and vents.

12. Apply two finish coats of paint to shop primed metal surface of all mechanical and electrical equipment, to match adjoining wall or ceiling surfaces. In addition to above, prime coat all unprimed surfaces. Principal items of this work include interior of hose cabinets, air grilles, ceiling diffusers, electric panels, telephone panels, access panels, conduit, outlet and pull boxes, ducts and pipes.

13. Miscellaneous Painting: Paint surfaces to be painted and not specifically described herein, with a product specifically manufactured or prepared for the material and surface; prime coat and two finish coats, as approved by Engineer.

14. Upon completion, remove all rubbish caused by this trade. Remove spots from floors, glass and other surfaces. Leave in a clean and orderly condition.

15. At the completion of other trades, touch up damaged surfaces as required.
3.07  COLOR IDENTIFICATION

A. All exposed and/or unburied pipe, including steel, copper and brass tubing, galvanized pipe, polyvinyl chloride pipe, fiberglass reinforced pipe, and stainless steel pipe, shall be identified by color to show its use/function. Color bands of an approved tape type may be used on PVC, FRP, and stainless steel pipe and all other pipe not readily susceptible to painted finish. Bands shall be adhesive type with extra strength and suitable for continuous duty at 250 degrees F. All markers shall have a protective silicone film.

B. Color shall be those listed in the COLOR CODE SCHEDULE.

3.08  STENCIL IDENTIFICATION

A. Both the direction of fluid flow and the name of the fluid in the pipe shall be stenciled on all piping at least once every twenty-five (25) feet and at every change of direction. Color bands shall be spaced at fifteen (15) foot intervals and every change in direction. The size in inches of the letters and color bands shall be as specified in the table below:

<table>
<thead>
<tr>
<th>Outside Diameter Pipe or Covering</th>
<th>Width of Color Band</th>
<th>Height of Legend Letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4 to 1-1/4</td>
<td>1</td>
<td>1/2</td>
</tr>
<tr>
<td>1-1/2 to 2</td>
<td>1</td>
<td>3/4</td>
</tr>
<tr>
<td>2-1/2 to 6</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>8 to 10</td>
<td>6</td>
<td>2-1/2</td>
</tr>
<tr>
<td>Over 10</td>
<td>6</td>
<td>3-1/2</td>
</tr>
</tbody>
</table>

B. The stenciled labels shall be abbreviated and conform to the piping abbreviations shown on COLOR CODE SCHEDULE. The labels shall be safety yellow, matching OSHA Safety Yellow. Engines and listed electrical items shall be color coded as follows:

White: Sherwin Williams F65W1
       Electrical (Excluding panels)

Gray: ANSI 61
      Electrical panels

Light Yellow: (EMWD)
             Engines

C. After the painting of process piping is complete, the Contractor shall stencil the tag numbers, as supplied by the Owner, of all process valves on the pipe adjacent to the
valve for pipe 2 inches and over. Characters shall be one inch high minimum and shall be oriented to be visible from the valve operating position. When the valve has extended operator shaft or chain operator, the number shall be placed both at the operating position and at the valve if practicable. The latter requirement does not apply if the valve is buried or in a pit. Valves in pipes under 2 inches shall have characters as large as the pipe will permit or at the Owner’s option, on an adjacent surface. Characters shall be preferably white; however, if this would not provide sufficient contrast to the pipe, the Owner may select another color. Paint used shall be of the same type and quality as used for painting the pipe.

3.09 APPLICATION, SPECIFIC - INDUSTRIAL

A. All coating components shall be mixed in exact proportions specified by the manufacturer. Care shall be exercised to insure all material is removed from containers during mixing and metering operations.

B. Catalyzed coatings shall not be applied beyond pot-life limits specified by manufacturer. Any required induction requirements shall be strictly followed.

D. Application shall be by conventional or airless spray method except as otherwise specified, or approved by the Engineer. Drying time between coats shall be strictly observed as stated in the manufacturer’s printed instructions.

E. When two or more coats are specified, where possible, each coat shall be of contrasting color.

F. Care shall be exercised during spray operations to hold the spray nozzle perpendicular and sufficiently close to surfaces being coated to avoid excessive evaporation of volatile constituents and loss of material into the air or the bridging of cracks and crevices. Reaching beyond limits of scaffold perimeter will not be permitted. All dryspray or overspray shall be removed as directed by Engineer and the area recoated.

3.10 FINAL TESTING OF INDUSTRIAL COATING

A. The final testing of the coating system shall include visual appearance, dry film thickness (DFT) measurements, hardness, cure, and adhesion testing and shall be performed in the presence of the Engineer.

B. **Visual Appearance** - The coating system shall be uniform in appearance and free of any defects as defined by SSPC’s Visual Comparison Manual.

C. **Dry Film Thickness** - The thickness of each coat of coating shall be checked with a non-destructive film thickness gauge in accordance with ASTM D7091, where applicable. An
instrument such as Tooke Gage should be used in accordance with ASTM D4138 if a destructive tester is deemed necessary by the Engineer. The testing of film thickness of flat (e.g. plate) surfaces shall be tested in accordance with SSPC-PA2. The sampling of structural members or irregular surfaces shall be tested in frequency and locations, as directed by the Engineer. Final dry film thickness applied to concrete surfaces shall be determined by cutting out dry coupons for cross sectional measurement.

D. **Hardness** - The hardness of catalyzed elastomeric coating systems shall be tested using a type Shore D hardness tester or device approved by the material manufacturer in accordance with ASTM D2240. The hardness of the final system shall be tested in areas randomly selected by the Engineer including any area suspected of being improperly mixed. The lining hardness after at least 48 hours shall be at least 70 when measured with a shore D hardness scale, or per the lining manufacturer’s written recommendations.

E. **Holiday Detection** - No pinholes or holidays will be permitted in any coating film. Upon completion of the final coat operations and after the required drying intervals, holiday detection shall be accomplished on all coated surfaces in intermittently submerged, submerged, or or severe environments (Service Conditions A, C, D, E, and I) in accordance with NACE SP0188. For thin film coatings, the Contractor shall obtain a letter from the coating manufacturer approving the use of high-voltage testing equipment, prior to any testing. Should the manufacturer not approve of high-voltage, a 67.5 volt low-voltage tester such as a Tinker and Rasor M-1 device shall be used for thin film systems. All holiday detection of coatings shall be performed in the presence of the Engineer.

F. **Cure Evaluation** - The proper cure of any inorganic zinc-rich (IOZ) primers and the final system(s) shall be verified. IOZ primers shall be evaluated in accordance with ASTM D4752. IOZ primers shall not be overcoated until fully cured. Organic, catalyzed coatings shall be tested in accordance with ASTM D5402 to verify adequate curing has been attained. If final cure has not been attained, the ventilation shall be continued until applied coating passes the solvent wipe test.

G. **Adhesion Testing** - Adhesion of the catalyzed elastomeric lining systems shall be tested in areas selected by the Engineer in accordance with ASTM D4541. The number and locations of the testing shall be at the sole discretion of the Engineer. Acceptable adhesion values shall be at least the lining manufacturer’s written recommendations for applications over concrete. The value obtained on the unlined concrete substrate itself shall be the minimum value requirement as long as the preparation of the substrate was found to be hard and sound by the Engineer.
3.11 CLEAN-UP

A. Upon completion of the work, all staging, scaffolding and containers shall be removed from the site or destroyed in a manner approved by the Engineer. Coating or paint spots upon adjacent surfaces shall be removed and the entire jobsite cleaned. All damage to surfaces resulting from the work of this section shall be cleaned, repaired, or refinished to the complete satisfaction of the Engineer at no cost to the Owner.

3.12 OMISSIONS

A. Care has been taken to delineate herein those surfaces to be coated. However, if coating or painting requirements have been inadvertently omitted from this section or any other section of the specifications, it is intended that all surfaces, unless specifically exempted herein, shall receive a first-class protective coating or paint system equal to that given the same type surface pursuant to these specifications.

3.13 COLOR CODE SCHEDULE

<table>
<thead>
<tr>
<th>Item</th>
<th>Color Code</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeration Air</td>
<td>Light Green</td>
<td>AA</td>
</tr>
<tr>
<td>Belt Press Return Water</td>
<td>Gray</td>
<td>BPRW</td>
</tr>
<tr>
<td>Building Drain</td>
<td>NA</td>
<td>BD</td>
</tr>
<tr>
<td>Compressed Air</td>
<td>Light Green w/Yellow</td>
<td>CA</td>
</tr>
<tr>
<td>Chlorinated Effluent</td>
<td>Blue</td>
<td>CE</td>
</tr>
<tr>
<td>Chlorine Gas</td>
<td>Yellow/Green Band</td>
<td>CG</td>
</tr>
<tr>
<td>Chlorine Solution</td>
<td>Yellow</td>
<td>CS</td>
</tr>
<tr>
<td>Cold Digested Sludge</td>
<td>Brown</td>
<td>CSL</td>
</tr>
<tr>
<td>Diesel Fuel</td>
<td>Yellow</td>
<td>DF</td>
</tr>
<tr>
<td>Digested Sludge</td>
<td>Brown</td>
<td>DSL</td>
</tr>
<tr>
<td>Digested Sludge Transfer</td>
<td>Brown</td>
<td>XSL</td>
</tr>
<tr>
<td>Digester Gs</td>
<td>Red</td>
<td>DG</td>
</tr>
<tr>
<td>Drain</td>
<td>NA</td>
<td>D</td>
</tr>
<tr>
<td>Electrical Panel (within bldg)</td>
<td>ANSI 61 - Gray</td>
<td>--</td>
</tr>
<tr>
<td>Electrical Conduit and Equipment (except panels)</td>
<td>White (Sherwin Williams F65W1)</td>
<td>--</td>
</tr>
<tr>
<td>Item</td>
<td>Color Code</td>
<td>Label</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Engine Coolant Water</td>
<td>Blue</td>
<td>ECW</td>
</tr>
<tr>
<td>Froth Spray</td>
<td>Blue</td>
<td>FS</td>
</tr>
<tr>
<td>Flotation Thickener Overflow</td>
<td>NA</td>
<td>FTO</td>
</tr>
<tr>
<td>Fresh Water</td>
<td>Light Blue</td>
<td>FW</td>
</tr>
<tr>
<td>Gravity Thickener Overflow</td>
<td>Gray/Yellow Bands</td>
<td>GTO</td>
</tr>
<tr>
<td>Grit</td>
<td>Brown</td>
<td>GRIT</td>
</tr>
<tr>
<td>Grit Washer Overflow</td>
<td>Gray</td>
<td>GWO</td>
</tr>
<tr>
<td>Ground Water Drain</td>
<td>NA</td>
<td>GWD</td>
</tr>
<tr>
<td>Heated Digested Sludge</td>
<td>Brown/Yellow Bands</td>
<td>HSL</td>
</tr>
<tr>
<td>High Temperature Water</td>
<td>Blue/Yellow Bands</td>
<td>HTW</td>
</tr>
<tr>
<td>Irrigation Water</td>
<td>NA</td>
<td>IW</td>
</tr>
<tr>
<td>Low Temperature Water</td>
<td>Blue/Orange Bands</td>
<td>LTW</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Light Yellow</td>
<td>NG</td>
</tr>
<tr>
<td>Oil Lines</td>
<td>Black</td>
<td>Oil</td>
</tr>
<tr>
<td>Polymer</td>
<td>Light Blue/Yellow Bands</td>
<td>POLY</td>
</tr>
<tr>
<td>Primary Tank Drain</td>
<td>Brown</td>
<td>PTD</td>
</tr>
<tr>
<td>Primary Sludge</td>
<td>Brown</td>
<td>PSL</td>
</tr>
<tr>
<td>Primary Scum</td>
<td>Brown</td>
<td>PSK</td>
</tr>
<tr>
<td>Raw Sewage</td>
<td>Brown</td>
<td>S</td>
</tr>
<tr>
<td>Return Digested Sludge</td>
<td>Brown</td>
<td>RDS</td>
</tr>
<tr>
<td>Return Water</td>
<td>Gray</td>
<td>RW</td>
</tr>
<tr>
<td>Secondary Scum</td>
<td>Brown</td>
<td>SSK</td>
</tr>
<tr>
<td>Sludge Bed Drain</td>
<td>NA</td>
<td>SBD</td>
</tr>
<tr>
<td>Sludge Heater Bypass</td>
<td>Brown</td>
<td>SLHB</td>
</tr>
<tr>
<td>Storm Water Drainage</td>
<td>NA</td>
<td>SWD</td>
</tr>
<tr>
<td>Thickened Sludge</td>
<td>Brown</td>
<td>TS</td>
</tr>
<tr>
<td>Thickener Dilution Water</td>
<td>Blue</td>
<td>TDW</td>
</tr>
<tr>
<td>Waste Activated Sludge</td>
<td>Brown</td>
<td>WAS</td>
</tr>
<tr>
<td>Waste Digested Sludge</td>
<td>Brown</td>
<td>WDS</td>
</tr>
<tr>
<td>Wash Water</td>
<td>Red</td>
<td>WW</td>
</tr>
<tr>
<td>Architectural System</td>
<td>Descriptive Color Code</td>
<td>Manufacturers' Paint Designation</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>PLANT BUILDINGS:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Surface</td>
<td>Tan</td>
<td>Rustoleum #865 (Dunes Tan)</td>
</tr>
<tr>
<td>Trim &amp; Doors</td>
<td>Dark Brown</td>
<td>Rustoleum #977 (Chestnut Brown)</td>
</tr>
<tr>
<td>Walls (metal)</td>
<td>Yellow-White</td>
<td>Dunn-Edwards #CH-60B (Parchment)</td>
</tr>
</tbody>
</table>

END OF SECTION 09900
PART 1 - GENERAL

1.01 SCOPE. This section covers architectural field painting of surfaces for appearance, including surface preparation, protection of surfaces, and other appurtenant work. Regardless of the number of coats previously applied, at least two field coats, in addition to any shop or field prime coats, shall be applied to all surfaces unless otherwise specified.

Dampproofing of concrete surfaces, protective coatings for equipment, and surfaces with severe service conditions that have been designated to be coated with a heavy-duty maintenance coating, are covered in other sections.

1.02 GENERAL. Cleaning, surface preparation, coating application, and thickness shall be as specified herein and shall meet or exceed the coating manufacturer's recommendations. When the manufacturer's minimum recommendations exceed the specified requirements, CONTRACTOR shall comply with the manufacturer's minimum recommendations. When equivalent products are acceptable to ENGINEER, CONTRACTOR shall comply with this Specification and the coating manufacturer's recommendations.

A. Governing Standards. All cleaning, surface preparation, coating application, thickness, testing, and coating materials (where available) shall be in accordance with the referenced standards of the following: American Water Works Association (AWWA), American National Standard Institute (ANSI), NACE International (NACE), The Society for Protective Coating (SSPC), NSF International (NSF), and ASTM requirements.

1.03 SUBMITTALS. CONTRACTOR shall submit color cards for all coatings proposed for use, together with complete descriptive specifications, to ENGINEER for review and color selection. Requests for review submitted directly to ENGINEER by coating suppliers will not be considered.

For the epoxy enamel, aliphatic polyurethane, and satin gloss latex emulsion finish coatings, a total of not more than five custom colors (excluding deep tone or high-level colors) may be required. The manufacturer's standard colors will be acceptable for all other coatings.
1.04 **QUALITY ASSURANCE.**

A. **Coating System Data Sheet Certifications.** When required, the coating applicator and coating manufacturer shall review and approve in writing the proposed coating manufacturer's written recommendations for the proposed coating system and the intended service. Any variations from the Specifications or the coating manufacturers published recommendations shall be submitted in writing and approved by the coating manufacturer. The coating manufacturer shall observe the surface preparation, mixing, and application of the protective coating systems and submit a written report of what has been observed and any additional recommendations.

1.05 **DELIVERY AND STORAGE.** All coating products shall be received and stored in accordance with the coating manufacturer's recommendations.

**PART 2 - PRODUCTS**

2.01 **ACCEPTABLE MANUFACTURERS.**

A. **Alternative Manufacturers.** In addition to the coatings listed herein, equivalent coatings of the following manufacturers will also be acceptable:

- ICI Devoe
- PPG
- MAB
- Rust-Oleum
- Sherwin-Williams

B. **Equivalent Coatings.** Whenever a coating is specified by the name of a proprietary product or of a particular manufacturer or vendor, the specified coating shall be understood as establishing the type and quality of coating desired. Other manufacturers' coatings will be accepted, provided that sufficient information is submitted to enable ENGINEER to determine that the proposed coatings are equivalent to those named. Information on proposed coatings shall be submitted for review in accordance with Section 01300, Submittals. Requests for review of equivalency will be accepted only from CONTRACTOR and will be considered only after the Contract has been awarded.

2.02 **MATERIALS.** All coatings shall be delivered to the job in original unopened containers with labels intact. Coatings shall be stored indoors and shall be protected against freezing. No adulterant, unauthorized thinner, or other material not included in the coating formulation shall be added to the coating for any purpose.
All coatings shall conform to the air quality regulations applicable at the location of use. Coating materials which cannot be guaranteed by the manufacturer to conform, whether or not specified by product designation, shall not be used.

CONTRACTOR shall be responsible for ensuring the compatibility of field coatings with each other or with the coatings on shop coated or previously coated surfaces. Coatings used in successive field coats shall be produced by the same manufacturer. Coatings used in the first field coat over shop coated or previously coated surfaces shall cause no wrinkling, lifting, or other damage to underlying coats.

A. Primers.

Universal Primer

Ameron "Amercoat 385 Epoxy", Carboline "Carboguard 888 Primer", or Tnemec "Series N27 S.T. Typoxy".

Epoxy Concrete Block Filler

Ameron "Amerlock 400BF Epoxy Block Filler", Carboline "Carboguard 954HB", or Tnemec "56-1500".

B. Intermediate and Finish Coatings.

Epoxy Enamel

Ferrous Metal Surfaces, Ameron "Amercoat 385 Epoxy", and Masonry or Concrete Carboline "Carboguard 890", or Tnemec "Series 69 Hi-Build Epoxoline II".

Aliphatic Polyurethane

Ameron "Amershield Aliphatic Polyurethane", Carboline "Carbothane 134HG", or Tnemec "Series 74 Endura-Shield".

Latex Emulsion

Acrylic containing at least 50 percent by weight nonvolatile solids.

Flat

Carboline "Carbocrylic 600", Sherwin-Williams "Weather Perfect Acrylic Latex Series B-36", or Tnemec "Series 6 Tneme-Cryl".
C. Anti -Graffiti System.

American Polymer Corp. “GSS Clear Coat”.

PART 3 - EXECUTION

3.01 SURFACE PREPARATION. All surfaces to be coated shall be clean and dry and shall meet the recommendations of the coating manufacturer for surface preparation. Freshly coated surfaces shall be protected from dust and other contaminants. Oil and grease shall be completely removed by use of solvents or detergents before mechanical cleaning is started. The gloss of previously coated surfaces shall be dulled if necessary for proper adhesion of topcoats.

Surfaces shall be free of cracks, pits, projections, or other imperfections that would interfere with the formation of a smooth, unbroken coating film, except for concrete block construction where a rough surface is an inherent characteristic.

When applying touchup coating or repairing previously coated surfaces, the surfaces to be coated shall be cleaned as recommended by the coating manufacturer and the edges shall be sanded or wire brushed and feathered or otherwise smoothed so that they will not be noticeable after they are coated. All coatings made brittle or otherwise damaged by heat of welding shall be completely removed.

A. Galvanized Surfaces. Galvanized surfaces shall be prepared for coating in conformity with the instructions of the manufacturer of the epoxy enamel. Any chemical treatment of galvanized surfaces shall be followed by thorough rinsing with clean water.

B. Ferrous Metal Surfaces. Ungalvanized ferrous metal surfaces shall be prepared for coating by cleaning using one or more of the following methods as specified: solvents (SSPC-SP1); blasting (SSPC-SP5, -SP6, -SP7, or -SP10); power tools (SSPC-SP3); or hand tools (SSPC-SP2). Oil and grease shall be completely removed in accordance with SSPC-SP1 before beginning any other cleaning method. Surfaces of welds shall be scraped and ground as necessary to remove all slag and weld spatter. Tools which produce excessive roughness shall not be used.
All ferrous metal surfaces which are specified to be coated with epoxy enamel shall have all welds ground smooth and blended and sharp edges ground smooth, if not previously prepared in the shop.

The cleaning methods and profiles specified herein are minimums, and if the requirements printed in the coating manufacturer’s data sheets exceed the limits specified, the value printed on the data sheets shall become the minimum requirement.

C. Ferrous Metal Surfaces–Non-immersion Service. Ferrous metal surfaces, including fabricated equipment, in non-immersion service shall be cleaned to the degree recommended by the coating manufacturer for surfaces to be coated with epoxy enamel, except galvanized surfaces. Blast cleaning to at least SSPC-SP6 shall be used where recommended by the coating manufacturer, and may be used elsewhere at the option of CONTRACTOR, provided that no dust is permitted to settle on adjacent wet coating. Surface profile shall be at least 15 percent of the dry film thickness specified for the coating system.

D. Concrete Surfaces. All concrete surfaces shall be free of objectionable substances and shall meet the coating manufacturer's recommendations for surface preparation. Any other surface preparation recommended by the coating material manufacturer shall be brought to ENGINEER's attention and may be incorporated into the work if acceptable to ENGINEER.

All concrete surfaces shall be dry when coated and free from dirt, dust, sand, mud, oil, grease, and other objectionable substances. Oil and grease shall be completely removed by use of solvents or detergents before mechanical cleaning is started.

New concrete shall have cured for at least 28 days before coating is applied as recommended by the material manufacturer. Concrete surfaces shall be tested for capillary moisture in accordance with ASTM D4263. There shall be no capillary moisture when coatings are applied on concrete.

All surfaces to be coated shall be cleaned in accordance with ASTM D4258 and abraded in accordance with ASTM D4259. Prior to application of the coating, the surfaces shall be thoroughly washed or cleaned by air blasting to remove all dust and residue. Spalled areas, voids, and cracks shall be repaired in accordance with Section 03300, Cast-in-Concrete, and as acceptable to ENGINEER. Fins and other surface projections shall be removed to provide a flush surface before application of coating.
Except where indicated otherwise, the concrete surfaces, including those with bug holes less than 1 inch in any dimension, shall be prepared when required and as recommended by the manufacturer, using an epoxy concrete block filler.

E. Concrete Block Surfaces. Voids and openings in concrete block surfaces shall be pointed. Interior surfaces to be coated with latex coating shall not be filled. All exposed exterior surfaces and surfaces to be coated with epoxy enamel, including the joints, shall be filled so that a continuous unbroken coating film is obtained.

F. Hardware. Hardware items such as bolts, screws, washers, springs, and grease fittings need not be cleaned prior to coating if there is no evidence of dirt, corrosion, or foreign material.

3.02 MIXING AND THINNING. Coating shall be thoroughly mixed each time any is withdrawn from the container. Coating containers shall be kept tightly closed except while coating is being withdrawn.

Coating shall be factory mixed to proper consistency and viscosity for hot weather application without thinning. Thinning will be permitted only as necessary to obtain recommended coverage at lower application temperatures. In no case shall the wet film thickness of applied coating be reduced, by addition of coating thinner or otherwise, below the thickness recommended by the coating manufacturer. Thinning shall be done in compliance with all applicable air quality regulations.

3.03 APPLICATION. Coating shall be applied in a neat manner that will produce an even film of uniform and proper thickness, with finished surfaces free of runs, sags, ridges, laps, and brush marks. Each coat shall be thoroughly dry and hard before the next coat is applied. In no case shall coating be applied at a rate of coverage greater than the maximum rate recommended by the coating manufacturer.

Coating failures will not be accepted and shall be entirely removed and the surface recoated. Failures include but are not limited to sags, checking, cracking, teardrops, fat edges, or delaminations.

A. Priming. Edges, corners, crevices, welds, and bolts shall be given a brush coat of primer before application of the primer coat. Special attention shall be given to filling all crevices with coating.

Abraded and otherwise damaged portions of shop-applied coating shall be cleaned and recoated as recommended by the manufacturer of the finish coating. Welded seams and other uncoated surfaces, heads and nuts of
field-installed bolts, and surfaces where coating has been damaged by heat shall be given a brush coat of the specified primer. Before the specified spot or touchup coating of metal surfaces, edges, corners, crevices, welds, and bolts in the area of the spot or touchup coating, shall be given a brush coat of primer. This patch, spot, or touchup coating shall be completed, and the paint film shall be dry and hard, before additional coating is applied.

B. Latex Coating. Latex coating shall be applied by brushing or rolling; spraying will not be permitted. Latex coating shall not be thinned excessively.

C. Epoxy Enamel. Epoxy enamel shall be applied in accordance with the coating manufacturer’s recommendations, including temperature limitations and protection from sunlight until topcoated.

Coatings shall not be applied to concrete surfaces in direct sunlight or when the temperature of the concrete is rising. Preferably the coating shall be applied when the temperature of the concrete is dropping.

When applying high build epoxy coatings with a roller or brush and where a dry film thickness of at least 4 to 6 mils per coat is required, two or more coats shall be applied to achieve the recommended dry film thickness equal to a spray applied coating.

D. Film Thickness. The total coating film thickness, including prime coat (if any), intermediate coats, and finish coat, shall be not less than the following:

<table>
<thead>
<tr>
<th>Type of Coating</th>
<th>Minimum Dry Film Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latex</td>
<td>3 mils</td>
</tr>
<tr>
<td>Epoxy enamel</td>
<td></td>
</tr>
<tr>
<td>Surfaces with first coat of epoxy enamel and final coat of aliphatic polyurethane</td>
<td>7 mils</td>
</tr>
<tr>
<td>Other surfaces (two coats)</td>
<td>10 mils</td>
</tr>
<tr>
<td>All other finishes</td>
<td>5 mils</td>
</tr>
</tbody>
</table>
E. **Weather Conditions.** Coatings shall not be applied, except under shelter, during wet, damp, or foggy weather, or when windblown dust, dirt, debris, or insects will collect on freshly applied coating. Coatings shall not be applied at temperatures lower than the minimum temperature recommended by the coating manufacturer or to metal surfaces such as tanks or pipe containing cold water, regardless of the air temperature, when metal conditions are likely to cause condensation. When necessary for proper application, a temporary enclosure shall be erected and kept heated until the coating has fully cured.

3.04 **REPAIRING FACTORY-FINISHED SURFACES.** Factory-finished surfaces damaged prior to acceptance by Owner shall be spot primed and recoated with materials equivalent to the original coatings. If, in the opinion of ENGINEER, spot repair of the damaged area is not satisfactory, the entire surface or item shall be recoated.

3.05 **PROTECTION OF SURFACES.** Throughout the Work, CONTRACTOR shall use drop cloths, masking tape, and other suitable measures to protect adjacent surfaces. CONTRACTOR shall be responsible for correcting and repairing any damage resulting from its or its CONTRACTORS' operations. Coatings spilled or spattered on adjacent surfaces which are not being coated at the time shall be immediately removed. Exposed concrete or masonry not specified to be coated which is damaged by coatings shall be either removed and rebuilt or, where authorized by Owner, coated with two coats of masonry coating.

3.06 **FIELD PRIMING SCHEDULE.** In general, surfaces of steel, cast iron, and equipment are specified to be shop primed. Any such surfaces which have not been shop primed shall be field primed. Damaged or failed shop coatings which have been determined unsuitable by ENGINEER shall be removed and the surfaces shall be field primed. Galvanized, aluminum, stainless steel, wood, and insulated surfaces shall be field primed. Primers used for field priming, unless otherwise required for repair of shop primers, shall be as follows:

<table>
<thead>
<tr>
<th>Surface To Be Primed</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Steel and Miscellaneous Steel, surfaces to be coated with:</td>
<td></td>
</tr>
<tr>
<td>Epoxy enamel</td>
<td>Same as finish coats.</td>
</tr>
<tr>
<td>Galvanized</td>
<td>Epoxy enamel.</td>
</tr>
<tr>
<td>Concrete surfaces to be coated with:</td>
<td></td>
</tr>
<tr>
<td>Epoxy enamel</td>
<td>Epoxy concrete block filler.</td>
</tr>
</tbody>
</table>
Concrete block to be coated with:

Epoxy enamel   Epoxy concrete block filler.

Surfaces specified to be field coated with clear finish coats need not be primed. Unless otherwise recommended by the coating manufacturer or specified herein, priming will not be required on concrete, or concrete block, or gypsum wallboard surfaces specified to be coated with latex coating, nor on metal surfaces specified to be coated with epoxy enamel coatings. Priming will not be required on surfaces to be marked with traffic marking paint. Concrete surfaces to be coated with epoxy enamel shall be filled with epoxy concrete block filler so that a continuous film is obtained, except where indicated otherwise.

3.07 COATING SCHEDULE. The following schedule lists coatings for intermediate and finish coats. All exposed surfaces, including sides and edges, shall be coated.

<table>
<thead>
<tr>
<th>Surface To Be Coated</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Surfaces</td>
<td></td>
</tr>
<tr>
<td>Structural and miscellaneous steel exposed to view inside buildings.</td>
<td>(Galvanized surfaces are not to be coated unless otherwise specified.)</td>
</tr>
<tr>
<td>Epoxy enamel (one finish coat)</td>
<td></td>
</tr>
<tr>
<td>HVAC Exterior galvanized metal ductwork</td>
<td>Epoxy enamel (one finish coat)</td>
</tr>
<tr>
<td>HVAC Ductwork exposed to view inside buildings, after proper priming.</td>
<td></td>
</tr>
<tr>
<td>Adjacent to ceilings.</td>
<td>Epoxy enamel (one finish coat).</td>
</tr>
<tr>
<td>Adjacent to walls.</td>
<td>Epoxy enamel (one finish coat).</td>
</tr>
<tr>
<td>Steel Doors and Frames.</td>
<td></td>
</tr>
<tr>
<td>Intermediate coat</td>
<td>Universal Primer</td>
</tr>
<tr>
<td>Finish Coat</td>
<td>Aliphatic polyurethane</td>
</tr>
<tr>
<td>Metal Decking, including galvanized</td>
<td>Epoxy enamel (one finish coat).</td>
</tr>
<tr>
<td>Concrete and Masonry Surfaces</td>
<td></td>
</tr>
<tr>
<td>All concrete and concrete block (except floors and surfaces scheduled to receive</td>
<td></td>
</tr>
</tbody>
</table>
other coatings, see Specification 09871) which are exposed to view in interior locations (two coats).

Walls and columns. Satin gloss latex emulsion.

Architectural Pre-Cast Concrete Panels

Horizontal and vertical accent bands
Main panel field
Sherwin Williams Navajo White
Sherwin Williams Basket Beige

Screen Wall Pre-cast Concrete Panels

Horizontal accent band
Main panel field
Sherwin Williams Basket Beige
Sherwin Williams Navajo White

Building and Screen Wall panels to receive anti-graffiti system after panel installation. Application of system shall extend to 14 feet 0 inch above finished floor.

Miscellaneous Surfaces.

Plastic surfaces, including PVC and FRP.

Indoors. Epoxy enamel.
Outdoors.

First coat. Epoxy enamel.
Finish coat. Aliphatic polyurethane.

Surfaces Not to Be Coated. Unless otherwise specified, the following surfaces shall be left uncoated:

Exposed aluminum, except ductwork.

Polished or finished stainless steel. Unfinished stainless steel, except flashings and counterflashings, shall be coated.

Nickel or chromium.

Galvanized surfaces, except piping, conduit, ductwork, and other items specifically noted.
Piping concealed in inaccessible plumbing chases and above suspended ceilings.

Rubber and plastics, except as specified.

Acoustical panel ceilings.

Exterior face of CMU.

Exterior concrete.

Surfaces specified to be factory finished.
SECTION 09961
ANTI-GRAFFITI COATINGS

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 surface preparation and field application of anti-graffiti coating systems to the exterior of the perimeter screen wall.

B. Related Sections include the following:

1. Division 7 Section "Water Repellent."
2. Division 9 Section "Painting and Protective Coatings" for general field painting.

1.3 SUBMITTALS

A. Product Data: For each coating system indicated. Coating shall be compatible with water repellent.

1. Material List: An inclusive list of required coating materials. Indicate each material and cross-reference the specific coating, finish system, and application. Identify each material by manufacturer's catalog number and general classification.

2. Manufacturer's Information: Manufacturer's technical information, including label analysis and instructions for handling, storing, and applying each material specified.

B. Certification by manufacturer that products supplied comply with requirements indicated that limit the amount of VOCs in coating products.

C. Samples for Verification: For each material to be applied, with texture to simulate actual conditions, on representative samples of the actual substrate.

D. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

E. Warranty.
1.4 QUALITY ASSURANCE

A. Applicator Qualifications: Engage an experienced applicator who has completed anti-graffiti coating system applications similar in material and extent to those indicated for Project, is certified by the manufacturer, and whose work has a record of successful in-service performance.

B. Source Limitations: Obtain coatings, and removal agent from the same manufacturer.

1.5 PERFORMANCE REQUIREMENTS

A. Provide anti-graffiti coating system complying with the following:

1. Permanent coating system.
2. Show no signs of deterioration or change of appearance after graffiti removal during the warranty period.
3. Capability of removing 100% of all types of paint and graffiti materials from treated surfaces without damaging the coating or the substrate.
4. Upon graffiti removal, no evidence of graffiti shall remain.
5. Capable of withstanding a minimum of 120 cleaning cycles without measurable coating deterioration.
6. Shall not increase dirt pick-up of substrate.
7. Meet the following test results for the following chemicals:
   a. MEK No effect after 5 days
   b. Carboxylic Acid No effect after 5 days
   c. 75% Phosphoric Acid No effect after 5 days
   d. 37% HCL 3 hours blister
   e. 50% Sulfuric Acid No effect after 5 days
   f. 20% NIT 68 hours blister

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in manufacturer's original, unopened packages and containers bearing manufacturer's name and label with the following information:

1. Name or title of material.
2. Product description (generic classification or binder type).
3. Manufacturer's stock number and date of manufacture.
4. Contents by volume, for pigment and vehicle constituents.
5. Thinning instructions.
6. Application instructions.
7. Color name and number.
8. Handling instructions and precautions.

B. Store materials not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature of 45 deg F. Maintain containers used in storage in a clean condition, free of foreign materials and residue.

1. Keep storage area neat and orderly. Remove oily rags and waste daily. Take necessary measures to ensure that workers and work areas are protected from fire and health hazards resulting from handling, mixing, and applying coatings.

1.7 PROJECT CONDITIONS

A. Apply coatings only when temperature of surfaces to be coated and surrounding air temperatures are between 45 and 95 deg F.

B. Do not apply coatings in snow, rain, fog, or mist; when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

1. Allow wet surfaces to dry thoroughly and attain temperature and conditions specified before proceeding with or continuing coating operation.

1.8 EXTRA MATERIALS

A. Furnish extra graffiti removal materials in quantities described below. Package coating materials in unopened, factory-sealed containers for storage and identify with labels describing contents.

1. Quantity: One full case.

PART 2 - PRODUCTS

2.1 ANTI-GRAFFITI SYSTEM / MANUFACTURER

A. Evonik Degussa Corporation; Protectosil Anti-graffiti or equal.

2.2 ANTI-GRAFFITI COATING MATERIALS

A. VOC Classification: Provide materials that comply with South Coast Air Quality Management District’s VOC classification.

B. Coatings shall meet requirements of the following:

1. ASTM B 117 and ASTM D 714 (salt spray minimum acceptable of 8000 hours).
2. ASTM D 530 (hardness)
3. ASTM D 412 (tensile strength and elongation)
PART 3 - EXECUTION

3.1 EXAMINATION

A. With Applicator present, examine substrates and conditions under which anti-graffiti coatings will be applied, for compliance with coating application requirements.

1. Apply coatings only after unsatisfactory conditions have been corrected and surfaces to receive coatings are thoroughly dry.

2. Start of application is construed as Applicator's acceptance of surfaces within that particular area.

B. Coordination of Work: Review other Sections in which primers or other coatings are provided to ensure compatibility of total systems for various substrates. On request, furnish information on characteristics of specified finish materials to ensure compatible primers.

1. If a potential incompatibility of primers applied by others exists, obtain the following from the primer Applicator before proceeding:
   a. Confirmation of primer's suitability for expected service conditions.
   b. Confirmation of primer's ability to be top coated with materials specified.

2. Notify Architect about anticipated problems before using the coatings specified over substrates primed by others.

3.2 PREPARATION

A. General: Remove plates, machined surfaces, and similar items already in place that are not to be coated. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and coating.

1. After completing coating operations, reinstall items that were removed; use workers skilled in the trades involved.
B. Cleaning: Before applying coatings, clean substrates of substances that could impair bond of coatings. Remove oil and grease before cleaning.

1. Schedule cleaning and coating application so dust and other contaminants from cleaning process will not fall on wet, newly coated surfaces.

C. Surface Preparation: Clean and prepare surfaces to be coated according to manufacturer's written instructions for each substrate condition and as specified.

1. Provide barrier coats over incompatible primers or remove primers and reprime substrate.

2. Cementitious Substrates: Prepare concrete, concrete masonry block, and cement plaster surfaces to be coated. Remove efflorescence, chalk, dust, dirt, grease, oils, and release agents. Roughen as required to remove glaze. If hardeners or sealers have been used to improve curing, use mechanical methods to prepare surfaces.

   a. Do not coat surfaces if moisture content exceeds that permitted in manufacturer's written instructions.

D. Material Preparation: Carefully mix and prepare coating materials according to manufacturer's written instructions.

1. Maintain containers used in mixing and applying coatings in a clean condition, free of foreign materials and residue.

2. Stir materials before applying to produce a mixture of uniform density. Stir as required during application.

3.3 APPLICATION

A. Application operation shall comply with CFC Sections 1503 and 1504.

B. General: Apply coatings according to manufacturer's written instructions.

1. Use applicators and techniques best suited for the material being applied.

   a. Do not apply coatings over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to forming a durable coating film.

   b. Allow sufficient time between successive coats to permit proper drying. Do not recoat surfaces until coating has dried to where it feels firm, does not deform or feel sticky under moderate thumb pressure, and application of another coat does not cause undercoat to lift or lose adhesion.
C. Application Over Cementitious Surfaces:

1. Base: Diluted to 1 percent concentration (1-part Protectosil Anti-graffiti to 14-part potable water).

2. Finish: 2 coats of full strength of coating (non-diluted).

D. Completed Work: Match approved Samples for color, texture, and coverage. Remove, refinish, or recoat work that does not comply with specified requirements.

3.4 FIELD QUALITY CONTROL

A. Demonstration: Apply alkyd-based graffiti to a 2 ft. sq. treated area selected by the Architect. 5 days minimum after application, demonstrate complete removal of the graffiti in the presence of the Architect.

3.5 CLEANING

A. Cleanup: At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

1. After completing coating application, clean spattered surfaces. Remove spattered coatings by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

3.6 PROTECTION

A. Protect work of other trades, whether being coated or not, against damage from coating operation. Correct damage by cleaning, repairing, replacing, and recoating, as approved by Architect, and leave in an undamaged condition.

1. Provide "Wet Paint" signs to protect newly coated finishes. After completing coating operations, remove temporary protective wrappings provided by others to protect their work.

2. At completion of construction activities of other trades, touch up and restore damaged or defaced coated surfaces. Comply with procedures specified in PDCA P1.

END OF SECTION 09961
SECTION 10140
SIGNAGE

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 the following:

1. Dimensional characters.
2. Panel signs.

1.3 DEFINITIONS


1.4 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 Verification: For each of the following products and for the full range of color, texture, and sign material indicated, of sizes indicated:

1. Dimensional Characters: Full-size Samples of each type of dimensional character (letter, number, and graphic element).
2. Acrylic Sheet: 8 by 10 inches (200 by 250 mm) for each color required.
3. Panel Signs: Not less than 12 inches (305 mm) square.
D. Sign Schedule: Use same designations indicated on Drawings.

E. Maintenance Data: For signs to include in maintenance manuals.

F. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. 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.

B. Source Limitations for Signs: Obtain each sign type indicated from one source from a single manufacturer.

C. Regulatory Requirements: Comply with applicable provisions in ADA-ABA Accessibility Guidelines.

1.6 COORDINATION

A. Coordinate placement of anchorage devices with templates for installing signs.

1.7 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.

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. Acrylic Sheet: ASTM D 4802, Category A-1 (cell-cast sheet), Type UVA (UV absorbing).
2.2 DIMENSIONAL CHARACTERS

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. ACE Sign Systems, Inc.
2. Advance Corporation; Braille-Tac Division.
4. ASI-Modulex, Inc.
5. Bunting Graphics, Inc.
6. Charleston Industries, Inc.
8. Grimco, Inc.
10. Metal Arts; Div. of L&H Mfg. Co.
15. Southwell Company (The).

B. Cast Characters: Produce characters with smooth flat faces, sharp corners, and precisely formed lines and profiles, free of pits, scale, sand holes, and other defects. Cast lugs into back of characters and tap to receive threaded mounting studs. Alloy and temper recommended by sign manufacturer for casting process used and for use and finish indicated. Comply with the following requirements.

2. Height: 6”-inches
3. Thickness: ½”-inch
4. Color(s): As selected by Architect from manufacturer’s full range.
5. Mounting: Concealed studs, noncorroding for substrates encountered.
6. Text message: six numbers for building address.
7. Location: 12’-0” above finish floor. Facing public street.

2.3 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:

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.
11. Grimco, Inc.
12. Innerface Sign Systems, Inc.
13. InPro Corporation
14. Matthews International Corporation; Bronze Division.
19. Signature Signs, Incorporated.
20. Supersine Company (The)

B. Exterior 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. Acrylic Sheet: ¼”-inch thick.
2. Edge Condition: As shown on drawings
3. Corner Condition: As shown on drawings
4. Mounting:
   a. Manufacturer's standard noncorroding anchors for substrates encountered.
5. Color: As selected by Architect from manufacturer's full range.

C. 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: Opaque acrylic sheet
2. Raised-Copy Thickness: Not less than 1/32 inch (0.8 mm).
D. Colored Coatings for Acrylic Sheet: For copy and background colors, provide colored coatings, including inks, dyes, and paints, that are recommended by acrylic manufacturers for optimum adherence to acrylic surface and are UV and water resistant for five years for application intended.

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

E. Panel Sign Schedule: As shown on drawings

2.4 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.

2.5 FABRICATION

A. General: Provide manufacturer's standard signs of configurations indicated.

   1. Conceal fasteners if possible; otherwise, locate fasteners where they will be inconspicuous.

2.6 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.

2.7 ALUMINUM FINISHES

A. Color Anodic Finish: Manufacturer's standard Class 1 integrally colored or electrolytically deposited color anodic coating, 0.018 mm or thicker, in dark bronze applied over a satin mechanical finish, complying with AAMA 611.
2.8 ACRYLIC SHEET FINISHES

A. Colored Coatings for Acrylic Sheet: For copy and background and frame colors, provide colored coatings, including inks, dyes, and paints, that are recommended by acrylic manufacturers for optimum adherence to acrylic surface and that are UV and water resistant for five years for application intended.

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.

B. Wall-Mounted Signs: Comply with sign manufacturer's written instructions except where more stringent requirements apply.

1. 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.

C. 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. Projected Mounting: Mount characters at projection distance from wall surface indicated.
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 10140
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 the following:
      1. Public-use washroom accessories.

1.3 SUBMITTALS
   A. Product Data: For each type of product indicated. Include the following:
      1. Construction details and dimensions.
      2. Anchoring and mounting requirements, including requirements for cutouts in other work and substrate preparation.
      3. Material and finish descriptions.
      4. Manufacturer's warranty.
   B. Maintenance Data: For toilet and bath accessories to include in maintenance manuals.

1.4 QUALITY ASSURANCE
   A. Source Limitations: For products listed together in the same articles in Part 2, provide products of same manufacturer unless otherwise approved by Architect.

1.5 COORDINATION
   A. Coordinate accessory locations with other work to prevent interference with clearances required for access by people with disabilities, and for proper installation, adjustment, operation, cleaning, and servicing of accessories.
   B. Deliver inserts and anchoring devices set into concrete or masonry as required to prevent delaying the Work.
1.6  WARRANTY

A.  Special Mirror Warranty: Manufacturer's standard form in which manufacturer agrees to replace mirrors that develop visible silver spoilage defects and that fail in materials or workmanship within specified warranty period.

1.  Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1  MATERIALS

A.  Stainless Steel:  ASTM A 666, Type 304, 0.0312-inch (0.8-mm) minimum nominal thickness, unless otherwise indicated.

B.  Fasteners:  Screws, bolts, and other devices of same material as accessory unit and tamper-and-theft resistant where exposed, and of galvanized steel where concealed.

C.  Mirrors:  ASTM C 1503, Mirror Glazing Quality, clear-glass mirrors, nominal 6.0 mm thick.

2.2  PUBLIC-USE WASHROOM ACCESSORIES

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.  A & J Washroom Accessories, Inc.
2.  American Specialties, Inc.
5.  General Accessory Manufacturing Co. (GAMCO).

B.  Toilet Tissue (Folded) Dispenser:

1.  Description: Folded-tissue dispenser with cover hinged at bottom.
4.  Material and Finish: Stainless steel, No. 4 finish (satin)
5.  Lockset: Tumbler type.
6.  Refill Indicators: Pierced slots at front.
C. Combination Towel (Folded) Dispenser/Waste Receptacle:
   1. Description: Combination unit for dispensing C-fold or multifold towels, with removable waste receptacle.
   2. Mounting: Surface mounted
      a. Designed for nominal projection of 4-inch (100-mm).
   3. Minimum Towel-Dispenser Capacity: 600 C-fold or 800 multifold paper towels.
   5. Material and Finish: Stainless steel, No. 4 finish (satin).
   7. Lockset: Tumbler type for towel-dispenser compartment and waste receptacle.

D. Liquid-Soap Dispenser
   1. Description: Designed for dispensing soap in liquid or lotion form.
   3. Capacity: 40 oz.
   5. Lockset: Tumbler type.

E. Grab Bar:
   1. Mounting: Flanges with concealed fasteners.
   2. Material: Stainless steel, 0.05 inch (1.3 mm) thick.
      a. Finish: Smooth, No. 4, satin finish on ends and slip-resistant texture in grip area.
   4. Configuration and Length: As indicated on Drawings

F. Seat-Cover Dispenser:
   1. Mounting: Surface mounted.
   4. Lockset: Tumbler type.

   Mirror Unit

   5. Frame: Stainless steel, adjustable tilt.
      a. Corners: Manufacturer's standard.
6. Integral Shelf: 5 inches (127 mm) deep.
   a. One-piece, galvanized steel, wall-hanger device with spring-action locking mechanism to hold mirror unit in position with no exposed screws or bolts.
   b. Wall bracket of galvanized steel, equipped with concealed locking devices requiring a special tool to remove.
8. Size: As indicated on Drawings.

2.3 UNDERLAVATORY GUARDS

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. Plumberex Specialty Products, Inc.
   2. TCI Products.
   3. Truebro, Inc.

B. Under-lavatory Guard

   1. Description: Insulating pipe covering for supply and drain piping assemblies, that prevent direct contact with and burns from piping, and allow service access without removing coverings.

2.4 FABRICATION

A. General: Fabricate units with tight seams and joints, and exposed edges rolled. Hang doors and access panels with full-length, continuous hinges. Equip units for concealed anchorage and with corrosion-resistant backing plates.

B. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to Owner’s representative.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Install accessories according to manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.

B. Grab Bars: Install to withstand a downward load of at least 250 lbf (1112 N), when tested according to method in ASTM F 446.

3.2 ADJUSTING AND CLEANING

A. Adjust accessories for unencumbered, smooth operation. Replace damaged or defective items.

B. Remove temporary labels and protective coatings.

C. Clean and polish exposed surfaces according to manufacturer's written recommendations.

END OF SECTION 10280
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 portable, hand-carried fire extinguishers and mounting brackets for fire extinguishers.

B. Related Sections:

1. Division 10 Section "Fire Extinguisher Cabinets."
2. Division 21 Section "Water-Based Fire-Suppression Systems" for hose systems, racks, and valves.
3. Division 23 Section "Commercial-Kitchen Hoods" for fire extinguishing systems provided as part of commercial-kitchen exhaust hoods.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rating and classification, material descriptions, dimensions of individual components and profiles, and finishes for fire extinguisher and mounting brackets.

B. Operation and Maintenance Data: For fire extinguishers to include in maintenance manuals.

C. Warranty: Sample of special warranty.

1.4 QUALITY ASSURANCE

A. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10, "Portable Fire Extinguishers."

B. Fire Extinguishers: Listed and labeled for type, rating, and classification by an independent testing agency acceptable to authorities having jurisdiction.
1. Provide fire extinguishers approved, listed, and labeled by FMG.

1.5 COORDINATION

A. Coordinate type and capacity of fire extinguishers with fire protection cabinets to ensure fit and function.

1.6 WARRANTY

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

1. Failures include, but are not limited to, the following:

   a. Failure of hydrostatic test according to NFPA 10.
   b. Faulty operation of valves or release levers.

2. Warranty Period: Six years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PORTABLE, HAND-CARRIED FIRE EXTINGUISHERS

A. Fire Extinguishers: Type, size, and capacity for each mounting bracket indicated.

1. 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:

   a. Amerex Corporation.
   b. Ansul Incorporated; Tyco International Ltd.
   c. Badger Fire Protection; a Kidde company.
   d. Buckeye Fire Equipment Company.
   e. Fire End & Croker Corporation.
   g. Kidde Residential and Commercial Division; Subsidiary of Kidde plc.
   h. Larsen’s Manufacturing Company.
   i. Moon-American.
   j. Pem All Fire Extinguisher Corp.; a division of PEM Systems, Inc.
   k. Potter Roemer LLC.
   l. Pyro-Chem; Tyco Safety Products.
2. Valves: Manufacturer's standard
3. Handles and Levers: Manufacturer's standard
4. Instruction Labels: Include pictorial marking system complying with NFPA 10, Appendix B.

B. Multipurpose Dry-Chemical Type in Steel Container: UL-rated 2-A:10-B:C, 5-lb (2.3-kg) nominal capacity, with monoammonium phosphate-based dry chemical in enameled-steel container.

2.2 MOUNTING BRACKETS

A. Mounting Brackets: Manufacturer's standard steel, designed to secure fire extinguisher to wall or structure, of sizes required for types and capacities of fire extinguishers indicated, with plated or black baked-enamel finish.

1. 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:
   a. Amerex Corporation.
   b. Ansul Incorporated; Tyco International Ltd.
   c. Badger Fire Protection; a Kidde company.
   d. Buckeye Fire Equipment Company.
   e. Fire End & Croker Corporation.
   g. Larsen's Manufacturing Company.
   h. Potter Roemer LLC.

B. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate as indicated by Architect.

1. Identify bracket-mounted fire extinguishers with the words "FIRE EXTINGUISHER" in red letter decals applied to mounting surface.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fire extinguishers for proper charging and tagging.

1. Remove and replace damaged, defective, or undercharged fire extinguishers.
3.2 INSTALLATION

A. General: Install fire extinguishers and mounting brackets in locations indicated and in compliance with requirements of authorities having jurisdiction.

1. Mounting Brackets: 40 inches above finished floor to top of fire extinguisher.

B. Mounting Brackets: Fasten mounting brackets to surfaces, square and plumb, at locations indicated.

END OF SECTION 10441
SPECIFICATIONS - DETAILED PROVISIONS
Section 11005 - General Mechanical and Equipment Provisions

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PART 1 - GENERAL

1.01 DESCRIPTION
These General Mechanical and Equipment Provisions, which apply to all systems and equipment, are hereby made a part of each and all of the separate Sections of this Specification. Contractor shall direct the attention of all Subcontractors and suppliers of mechanical and related appurtenances for the Work to the provisions of the Contract Documents located in these specifications.

1.02 MANUFACTURER'S EXPERIENCE
Unless specifically named in the detailed Specifications, a manufacturer shall have furnished equipment of the type and size specified which has demonstrated successful operation and is in regular use.

1.03 FACTORY INSPECTION
The District or its representative may inspect fabricated equipment at the factory without cost to the Contractor. The Contractor shall notify the District in sufficient time so that factory inspection can be arranged. Factory inspection will be made after manufacturer has performed satisfactory checks, adjustments, tests and operations. Approval of equipment at the factory only allows the manufacturer to ship the equipment to the site, and does not constitute final acceptance by the District.

1.04 STANDARD OF QUALITY
Items of equipment are specified by the name of the manufacturer for the purpose of establishing a standard of quality and acceptable experience. Substitute equipment will be acceptable if it can be demonstrated to the District that the substitute is in strict accordance with the Specifications and equal in quality to those models specifically named. Manufacturers specified have been determined by the District to meet or exceed the minimum acceptable standard for the designated equipment style and model. Refer to the General Provisions for requirements pertaining to substitutions and equals. All mechanical equipment furnished under the Specification shall be new and of current design.

1.05 ADAPTATION OF EQUIPMENT
No responsibility for alteration of a planned structure to accommodate substitute equipment will be assumed by the District. Equipment which requires alteration of the structures will be considered only if the Contractor assumes all responsibility for making and coordinating all necessary alterations. All revisions to structures, mechanical, electrical, or other work made necessary by such substitution shall be approved by the District and the cost of said revisions, including cost of redesign, shall be made at the Contractor's expense. Refer to General Provisions.
General Mechanical and Equipment Provisions
Section 11005 – 2

A. **Horsepower Ratings.** Horsepower ratings specified and/or shown for the proposed equipment are in accordance with the best information available to the District. In the event any equipment item proposed by the Contractor should require motors with larger horsepower rating than indicated on Electrical Drawings, it shall be the Contractor’s responsibility to provide the proper control equipment, required modifications to motor control centers, starting equipment, feeder and branch circuit, and accessories as required to make the installation comply with the electrical code and to prevent excessive voltage drop without added cost to the District.

B. **Equipment.** Where equipment to be furnished is installed in an existing enclosure or adjacent to existing equipment, the Contractor shall field check the dimensions of existing equipment, location of conduits, etc., and shall familiarize himself with all existing conditions and difficulties to be encountered in performing such work.

1.06 **GUARANTEES AND WARRANTIES**
The Contractor shall guarantee all equipment in accordance with the Conditions of the Contract. In addition to the general guarantee requirements, equipment guarantee shall cover (1) faulty or inadequate design; (2) improper assembly or erection; (3) defective workmanship or materials; and (4) leakage, breakage, or other failure. For equipment bearing a manufacturer's warranty in excess of one (1) year, furnish a copy of the warranty to District with District named as beneficiary. The period of all guarantees shall be initiated from the date of the District written acceptance of the Work.

1.07 **SUBMITTALS**
Refer to Section F Labor and Construction, F-30 "Submittals" and to specific Divisions and Sections for additional submittal requirements.

A. **Shop Drawings.** Shop drawings shall be submitted to the District in complete sets indexed by Specification paragraph and Drawing number describing the various equipment items or systems. Unless otherwise specified or directed, submit shop drawings for all mechanical equipment specified herein.

B. **Earthquake Design Data.** Submit with the shop drawings complete calculations or test results, details of constructions, and method of attachment for all manufactured products showing compliance with Paragraph 3.11, "Earthquake Design and Restraint." The calculations and details shall be signed by a Professional Engineer who has demonstrated proficiency in Structural Engineering or Civil Engineering and is registered in the State of California.

C. **Instruction Manuals.** Prepare and submit instruction manuals covering all mechanical equipment and machinery specified herein.
D. Manufacturers' Certified Reports. Each equipment manufacturer, or his authorized representative, shall submit a notarized written report with respect to his equipment certifying that (1) the equipment has been properly installed and lubricated under his supervision, (2) the equipment is in accurate alignment, (3) he was present when the equipment was placed in operation, (4) he has checked, inspected, and adjusted the equipment as necessary, (5) the equipment is free from any undue stress imposed by connecting piping or anchor bolts, (6) has been satisfactorily operated under full load conditions, (7) he has inspected his equipment during the operational demonstrations and system validation tests to the extent specified, and (8) the equipment is fully covered under the terms of the guarantee.

E. Submittals For Operational Demonstration and System Validation Tests

1. Operation Demonstration. When the Contractor's application for a progress payment equals or exceeds 75% of the Contract value for the first time, submit a detailed and comprehensive procedure plan for performance of each operation demonstration required. Identical equipment items may be covered under one plan. Include an estimated date and duration for each procedure and personnel required.

2. System Validation Tests. When the Contractor's application for a progress payment equals or exceeds 75% of the Contract value for the first time, submit a detailed and comprehensive procedure plan for performance of each separate validation test and for each validation test that covers two or more systems. Each procedure plan shall describe and itemize the involved system, including associated electrical equipment and instrumentation and control systems, and shall include evidence of an organized step-by-step procedure properly coordinating the efforts of various trades and manufacturers' representatives involved and of the operation of the facilities. Procedures shall include an estimated duration and date for each procedure and the personnel required.

3. Procedure Plan Information. In addition to the information specified above, each procedure plan shall include the following information as applicable.

   a) Description of temporary procedure facilities, including Drawings and sketches as required to fully illustrate the facilities.

   b) List of test materials and estimated quantities.

   c) List of instruments, measuring and recording devices, and other test equipment, whether a part of the plant or furnished separately for temporary use.

   d) Names of supervising and inspecting manufacturers.
e) Complete listing of all functional parameters to be observed and recorded.

f) Recording intervals.

4. Records Materials. Submit samples of the forms, charts, and other materials to be used in recording demonstration and validation test results.

5. Results. Within 10 days after completion of each procedure plan submit 3 copies of all recordings and results of all operational demonstrations and system validation tests.

F. Electric Motors. Conform with applicable requirements specified in Sections 16150 and 16151 herein.

1.08 PRODUCT DELIVERY, STORAGE AND HANDLING
Box, crate, or otherwise enclose and protect equipment during shipment, handling, storage, and following installation until final acceptance of the project. Keep equipment dry and covered from exposure to weather. Store pumps, motor, electrical equipment, and equipment having anti-friction or sleeve bearings in weathertight storage facilities. Lift large equipment items only at the points designated by manufacturer.

A. Factory Painted Surfaces. Protect against impact, abrasion, discoloration, and other damage. Repair damage as directed and approved (Refer to Section 09871).

B. Electrical Equipment. Maintain electrical equipment, controls, and keep insulation dry at all times. Keep heaters in equipment connected and operating until equipment is placed in operation.

1.09 JOB CONDITIONS
Drawings are diagrammatic and show the intended arrangement of principle apparatus, piping, and appurtenances. Conform to Drawings as closely as possible and exercise care to secure approved headroom and space conditions, neat arrangement of piping, valves, hangers, and like items, and to overcome structural interferences. Verify dimensions and conditions at the place of installation, and install materials and equipment in the available spaces. Submit written details and reasons for proposed deviations from Drawings and Specifications, and do not deviate therefrom unless authorized by Field Order or Change Order. If approved changes require alteration of structures or related work, make such alterations as approved in advance by District at no additional cost to District.

1.10 EQUIPMENT
All equipment furnished shall be complete, ready for installation and operation. All bolts, nuts, washers, mounting plates, bed plates, bases, anchor bolts and other miscellaneous items necessary to form a complete, installed, operational system shall be furnished whether specifically specified or not.
PART 2 - PRODUCTS

2.01 MATERIALS AND WORKMANSHIP
All equipment furnished shall be new and guaranteed free from defects in materials, design, and workmanship. It shall be the manufacturer’s responsibility to ascertain the conditions and service under which the equipment will operate and to warrant that operation under these conditions shall be successful. All parts of the equipment shall be amply proportioned for all stresses that may occur during fabrication, erection, and intermittent or continuous operation.

All equipment shall be designed, fabricated, and assembled in accordance with the best modern engineering and shop practice. Individual parts shall be manufactured to standard sizes and gauges so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except as required by tests. Materials shall be suitable for service conditions. Iron castings shall be tough, close-grained gray iron free from blowholes, flaws, or excessive shrinkage and shall conform to ASTM A48. Except where otherwise specified, structural and miscellaneous fabricated steel used in items of equipment shall conform to the Standards of the American Institute of Steel Construction. All structural members shall be considered as subject to shock or vibratory loads. Unless otherwise specified, all steel which will be submerged, all or in part, during normal operation of the equipment shall have a minimum nominal thickness of 1/4-inch. Provide equipment and materials suitable for the service conditions and meeting standard specifications such as ANSI, ASME, AWWA, ASTM, NEMB, UBC, and UL. The location of the fabricator and his shop schedule shall be furnished to the District prior to the beginning of fabrication so that the District can schedule shop inspection.

2.02 LUBRICATION

A. Lubricants. Provide lubricants of types recommended by equipment manufacturers, quantities sufficient for consumption prior to completion, testing, and final acceptance.

B. Lubrication Systems. Lubrication of equipment shall ensure constant presence of lubricant on all wearing surfaces. Lubricant fill and drain openings shall be readily accessible. Easy means for checking the lubricant level shall be provided. Prior to testing and/or operation, the equipment shall receive the prescribed amount and type of lubricant as required by the equipment manufacturer. Equipment lubrication systems shall be systems that require attention during start up of shut down, and shall not waste lubricants.
2.03 STRUCTURAL STEEL FABRICATIONS
Conform to "Code of Standard Practice for Steel Buildings and Bridges" and "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" of the AISC unless otherwise indicated or specified. Design all fabrications for dynamic and vibratory loadings. Use structural steel shapes conforming to ASTM A36, A440, A500, A501, A570, A618, or equal, as applicable. Conform welding to AWS D1.1 Structural Welding Code. Galvanized specified items in accordance with ASTM A123, A153, or A386 as applicable; use galvanized bolts and fasteners with galvanized assemblies.

2.04 EQUIPMENT BASES AND BEDPLATES
Mount equipment assemblies on a single heavy cast iron or welded steel bedplate unless otherwise shown or specified. Provide bases and bedplates with machined support pads, tapered dowels for alignment or mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits. Continuously weld seams and contact edges between steel plates and shapes, and grind welds smooth. Do not support machinery or piping on bedplates other than that which is factory installed. Provide jacking screws in equipment bases and bedplates to aid in leveling prior to grouting. Provide plates of minimum thickness of 1/4-inch. Pump bedplates shall include a drip lip and provisions for directing leakage to a single disposal point.

2.05 ANCHORS AND SLEEVES
Each equipment manufacturer shall furnish the required anchor bolts, nuts, washers, and sleeves of adequate design for securing bases and bedplates to concrete bases. Provide sleeves of at least 1-1/2 times anchor bolt diameter. Anchor bolts shall be Type 316 stainless steel. Provide anchor bolts of length to allow for 1-1/2 inch of grout under baseplates and adequate anchorage into structural concrete unless otherwise shown or specified. Conform to designs for attachments to resist seismic forces, as applicable.

2.06 SAFETY GUARDS
Cover belt or chain drives, fan blades, couplings, exposed shafts and other moving or rotating parts on all sides with safety guards conforming to all Federal, state, and local codes and regulations pertaining; conform to the most restrictive requirements. Safety guards shall be free of all sharp edges and corners. Use corrosion-resistant materials at least equivalent to hot-dip galvanized steel. Safety guards shall be fabricated from 16USS gauge, or heavier, galvanized or aluminum-clad steel or 1/2-inch mesh galvanized expanded metal. Design guards for easy installation and removal. Provide necessary supports, accessories, and fasteners, of hot-dip galvanized steel or stainless steel. Design guards in outdoor locations to prevent entrance of rain and dripping water.

2.07 DRIVE UNITS
Provide drive units designed with a AGMA rating and service factor suitable for 24 hour continuous duty service under operating load, constructed to preclude oil leakage around shafts. Drive unit housings shall be constructed of high grade cast iron, welded steel, or other suitable material. Thermal rating of each unit shall exceed the design load or proper cooling devices shall be provided. All drives shall be designed specifically for the service conditions under which they are to operate.
A. **Motor Ratings.** Provide drive motors having nameplate horsepower rating at least equal to 110 percent of the theoretical brake horsepower required to drive equipment under full load for conditions specified, including all losses in speed reducers and power transmission. Refer also to Section 16150.

B. **V-Belt Drives.** Equip each V-belt with a sliding base or other suitable tension adjustment. Where motors are mounted above the driven machine on a pedestal, the belt tensioning shall be accomplished by four studs which are double nutted to the motor plate to raise and lower the motor plate. Hinges with jacking screw to tension the belts shall not be used. Provide drives having a service factor of at least 1.6 at maximum torque using nameplate rating of driving motor.

### 2.08 GEARS

Provide oil-lubricated totally-enclosed gear reducers and increasers.

A. **Service Ratings.** Each gear shall have a nameplate service horsepower rating equal to the nameplate rating of the driving motor. Each gear shall have mechanical and thermal capacity equal to, or greater than an equivalent horsepower determined by multiplying the service horsepower rating by the specified service factor recommended by AGMA for heavy duty service, except each set of worm gears shall have a minimum service factor of 1.50.

B. **Thermal Rating.** Obtain thermal rating for the equivalent horsepower without auxiliary cooling equipment such as heat exchangers. Design units to operate continuously for the conditions specified in a location where ambient temperatures vary from 30° to 130° F. If a cooling coil is required, provide minimum 1-inch diameter tubing and a 1-inch solenoid supply water valve with the gear.

C. **Bearings.** Provide anti-friction bearings throughout, designed to give 20,000 hours B100 life for the specified horsepower in continuous operation, of proportions, mounting and adjustment consistent with acceptable modern practices for applied radial and thrust loads at speeds involved. Provide thrust bearing rates at 1-1/2 times the maximum thrust loadings involved.

D. **Gear Nameplates.** Equip each gear with an AGMA nameplate which shows service horsepower, actual service factor for actual mechanical or thermal rating as applicable, and AGMA gear Class I rating.

### 2.09 ELECTRICAL MOTORS FOR MECHANICAL EQUIPMENT

Conform with applicable requirements of Division 16.
2.10 CONTACTS
For interlock or failure indicating contacts specified to be supplied as part of equipment, provide SPDT switches rated for 120 VAC, 60 Hz at 5 amperes resistive or 3 amperes inductive loading, terminated at screw-type barrier strips in a NEMA 4 enclosure, unless otherwise shown or specified.

2.11 GAUGES
Gauges shall be installed in the suction (where applicable) and discharge piping of each pump and blower. The gauges shall be 4-inch diameter, liquid filled and shall include a petcock (Corp stop) between the pump/blower piping and the gauge. For solids bearing or corrosive fluids, a diaphragm gauge isolator shall be provided. Suction gauges shall be of the compound type and shall have a range as shown on the Drawings. Discharge gauge ranges shall be a standard commercially available range as shown on the drawings.

2.12 NAMEPLATES AND DATA PLATES
Provide Type 302, 304, or 316 stainless steel nameplates of ample size with embossed or preprinted lettering, fastened to the equipment in a prominent place with corrosion-resisting pins. On nameplates, display manufacturer, serial number, date of manufacture, model number and essential operating characteristics. Inscribe data plates with specific or directed information.

2.13 PAINTING
Conform to applicable requirements of Section 09871 "Coating System for Water Pumping Plants" and following requirements unless modified or superceded under other Sections.

A. Factory Painting. On mechanical equipment, drives, starters, control panels and other similar self-contained or enclosed components, apply a factory primer and high-quality oil-resistant baked industrial enamel finish. Paint or otherwise protect surfaces that are inaccessible after assembly by a method which provides protection for the life of the equipment.

B. Shop Priming. Apply one or more shop coats of metal primer on surfaces to be finish painted at the site to protect surfaces until finished. Use primers specified for the required paint system in Section 09871.

C. Rust Preventive. Coat machined, polished, or other ferrous surfaces, and non-ferrous surfaces, which are not to be painted, with rust preventive compound, Dearborn Chemical No-Ox-Id 2W, Houghton Rust Veto 344, Rust-Oleum 4-9, or approved equal.
PART 3 - EXECUTION

3.01 COORDINATION
The Drawings show in a diagrammatic form the arrangements desired for the principle apparatus, piping, and similar appurtenances, and shall be followed as closely as possible. Proper judgment must be exercised in carrying out the work to secure the best possible headroom and space conditions throughout, to secure neat arrangement of piping, valves, fixtures, hangers, and similar appurtenances, and to overcome local difficulties and interferences of structural conditions wherever encountered.

The Contractor shall take all measurements for his work at the installation sites, verify all subcontractor drawings and be responsible for the proper installation, within the available space for the apparatus specified and shown on the Drawings, and must secure the approval of the District for any variations before making any changes.

Refer to pertinent Sections for items of equipment to be assembled of several components under the unit responsibility of one manufacturer. To coordinate this requirement, the Contractor shall monitor and verify the unit responsibility processes and submit the following information to the District in writing on a monthly basis:

A. Shipment dates of the various components to the unit responsibility manufacturers.

B. Scheduled dates of factory tests by unit responsibility manufacturers.

C. Scheduled shipments dates to site of unit responsibility items.

D. Scheduled arrival date, installation date and start-up date.

3.02 INSPECTION
Inspect each item of equipment for damage, defects, completeness, and correct operation before installing. Inspect previously installed related work and verify that it is ready for installation of the equipment.

3.03 PREPARATION
Prior to installing equipment, ensure that installation areas are clean and that concrete or masonry operations are completed. Maintain the areas in a broom-clean condition during installation operations. Clean, condition, and service equipment in accordance with the reviewed Instruction Manuals and requirements in other Sections of these Specifications before installing.
3.04 MANUFACTURERS' SUPERVISION AND INSTALLATION CHECK
Each equipment manufacturer shall furnish the services of an authorized representative specially trained and experienced in the installation of his equipment to (1) supervise the equipment installation in accordance with the reviewed Instruction Manual, (2) be present when the equipment is first put into operation, (3) inspect, check, adjust as necessary, and approve the installation, (4) repeat the inspection, checking, and adjusting until all trouble or defects are corrected and the equipment installation and operation are acceptable, (5) witness and supervise operational demonstrations and system validation tests to the extent specified, and (6) prepare and submit the specified Manufacturers' Certified Report. Include all costs for representatives service in the Contract Price.

3.05 INSTALLATION

A. **Structural Fabrications.** Conform to the AISC Code and Specification references in Article "Structural Steel Fabrications."

B. **Equipment.** Conform to reviewed Instruction Manuals. Employ skilled craftsmen experienced in installation of the types of equipment specified. Use specialized tools and equipment, such as precision machinist levels, dial indicators, gauges, and micrometers, as applicable. Produce acceptable installations free of vibration or other defects.

C. **Anchor Bolts.** Deliver bolts with templates or setting drawings and verify that bolts are correctly located before structural concrete is placed.

D. **Base and Bedplate Grouting.** Do not place grout until initial fitting and alignment of connected piping is completed. Level and align equipment on the concrete foundations, then entirely fill the space under base or bedplates with grout. Bevel exposed grout at 45 degree angle, except round exposed grout at horizontal surfaces for drainage. Trowel or point exposed grout to a smooth dense finish and damp cure with burlap for three days. When grout is fully hardened, remove jacking screws and tighten nuts on anchor bolts. Check the installation for alignment and level, and perform approved corrective work as required to conform to the tolerances given in the applicable Instruction Manual.

3.06 FIELD QUALITY CONTROL

A. **General.** All costs for performing operational demonstrations and system validation tests shall be included in the Contract Price, and no extra payment will be made to the Contractor due to overtime, weekend, or holiday labor costs required to perform and complete the demonstrations and validation tests. Requirements specified in this Article are in addition to the demonstration and test requirements specified under other Sections of these Specifications.
1. Operational Demonstration and Systems Validation Testing shall be performed by the Contractor in accordance with the approved procedure plans to demonstrate to the District's satisfaction that:

   a) All components of the process systems defined herein, the complete systems, and the new plant systems are fully completed and operable.

   b) All units, components, systems, and the entire plant systems operate with the efficiency, repeatability, and accuracy indicated and specified.

   c) All components, systems, and the entire plant conform to the Contract Documents and the reviewed shop drawings, samples, construction manuals, materials lists, and other reviewed submittals.

2. Scope of Demonstrations and Validation Testing. Operational demonstrations and system validation tests are required for all work, equipment, and systems specified in these Specifications including all associated and related electrical systems and control devices.

   a) Equipment and work to be operationally demonstrated are defined as individual equipment items such as pumps, compressors, mixers, sludge collecting mechanisms, belt press and like equipment items. Demonstrations shall be performed simultaneously on groups of identical equipment items and groups of items supplied by one manufacturer to the extent feasible.

   b) Systems to be validation tested are defined as complete systems that perform a discrete process function of the plant such as chemical systems, sludge collection system, sludge dewatering system, and similar systems. Each system shall include associated structures, tanks, piping, utilities, instrumentation and controls, and like related items. Two or more separate systems shall be validation tested simultaneously when necessary to validate an entire discrete plant function.

3. Prerequisite Conditions. Operational demonstrations and validation testing shall not commence for any equipment item or system until all related structures, piping, electrical, instrumentation, control, and like work has been installed, tested, and connected in compliance with the pertaining requirements specified elsewhere in the Specifications.
4. **Demonstration and Testing Materials.** Furnish materials, natural gas and/or electrical power for operation demonstrations and validation tests. Use fresh water to fill tanks, wells, piping, and systems that contain water or wastewater in normal operation. Use the specified chemicals or chemical systems but do not exceed the "in service" concentrations. Furnish temporary facilities as required such as by-pass or re-circulation piping, diversions, storage, and similar facilities. Use procedures that conserve testing materials and avoid wastage, especially with respect to large quantities of fresh water and electrical power.

5. **Inspection and Supervision by Manufacturers.** Perform operational demonstrations and system validation testing under continuous inspection by the District. Technical representatives of the various equipment manufacturers shall be present at the start of the operational demonstrations, shall examine their equipment at least twice near the beginning and end of the validation tests, shall supervise the start up and adjustment procedures, and shall perform all other services necessary for the manufacturer's certified reports required herein.

6. **Correction of Defects.** Immediately correct all defects and malfunctions disclosed by demonstrations and validation tests using approved methods and new materials for repairs as required. Interruption time necessary for corrective work shall be added to the specified total demonstration and validation test periods.

7. **Acceptance.** Satisfactory completion and approval of required operational demonstrations and system validation testing is one of the conditions precedent to the District's acceptance of the work and does not constitute final acceptance. Refer to the Conditions of the Contract.

B. **System Validation Tests.** All equipment components of each system shall have successfully completed the required operational demonstration before the system is validation tested. Perform validation testing in accordance with the approved procedure plan.

1. **Test Period.** Test each system, including standby systems, by continuous operation in "in-service" condition for not less than 24 consecutive hours, with no interruptions except for normal maintenance or corrective work.

2. **Testing Methods.** Operate systems continuously 24 hours a day under constant inspection of trained operators. Cycle system operation from full load to light load and back to full load each 24 hours; cause variable speed equipment to cycle through the applicable speed range at a steady rate of change. Induce simulated alarm and distressed operating conditions, and test controls and protective devices for correct operation in adjusting system functions or causing system shutdown.
3. Simulation of Conditions. Subject to Contractor's request and District's review in each case, the Contractor may simulate certain operating conditions relating to flow rates, water levels, and malfunctions. Permission for simulations will be granted only where it is unwise or impossible to obtain the conditions covered by the capability of ranges or equipment. The simulation methods shall reflect reasonable anticipated operating conditions.


a) Flow Metering Systems shall be tested at not less than 3 values corresponding approximately to a minimum, average and maximum capacity, respectively.

b) Liquid Level Indicating Systems shall be tested at not less than 5 levels corresponding approximately to low, average, normal, maximum and high alarm levels, respectively. Low-low and high-high level alarms and system reaction shall also be tested where equipment or instruments are required to react to such conditions.

c) Remotely Controlled Valves shall demonstrate suitable operation both from local control and remote controls. As a minimum, these procedures shall include full-open and full-close positioning. Each test shall be repeated not less than 3 times for non-throttling and non-modulating valves. In addition to these minimum requirements, and subject to approval, all throttling valves and modulating valves shall be operated at not less than 3 intermediate positions and shall demonstrate the ability of each valve to hold the set position under operating conditions.

d) Variable Speed Equipment shall demonstrate accurate response to speed controlling devices and controls within the required operating ranges. Actual output shaft speeds of manually adjustable speed equipment shall be validated by measurement of shaft speeds versus speeds shown by equipment instruments.

5. Automatic Response of Equipment. Response of equipment to appropriate manual or automatic controls, or combinations of both automatic and manual controls, shall be demonstrated to be correct and accurate. Where applicable, all components shall be tested for both manual and automatic operation. Where a component performs more than one function, every function shall be validated.

a) Pumping Equipment shall respond accurately and reliably to liquid level, pressure and/or flow rate signals from appurtenant reservoirs, pipes or wet wells. Automatic alternation and back-up pump functions shall also be validated.
b) Auxiliary Equipment Items such as automatic samplers, annunciators, alarms, and like items shall respond accurately and reliably to every condition for which they are programmed, in the manner specified.

C. **Recording of Data.** Neat and comprehensive records of each operational demonstration or validation test shall be maintained by the Contractor. Each portion of the demonstration or validation procedure shall be described with all components itemized. Records shall be prepared on forms in a step-by-step fashion paralleling the approved plans. Forms shall list for each condition:

- Step taken;
- Result anticipated;
- Result obtained;
- If incorrect, corrective action taken; and
- Retest result.

The last two steps shall be repeated until all systems operate as required.

1. **Recording Devices.** Instruments, gauges, and other sensor and display devices forming a part of the various systems shall be employed for data acquisition to the extent applicable. The Contractor shall furnish all other instruments, gauges, recorders, and test devices as required, types conforming to the approved procedure plans.

2. **Information and Intervals.** All applicable data such as, but not limited to, water and other liquid levels, pressures, head differentials, duration of runs, instrument readings, chemical feed rates, voltage settings, drive speeds, motor running currents, torque, voltage, GPM, pressures, clarity, residual chlorine and related information, as applicable, and in accordance with the approved procedure plans, shall be recorded at the start and finish of every operational demonstration and at maximum 8-hour intervals during system validation tests, unless shorter intervals are specified elsewhere.

3. **Repetitions.** When a repeat of the same demonstration or validation test is required to verify the results, the repeat procedure shall be indicated on the recorded date by numerical indication, date, and time.

3.07 **CONSOLIDATION OF DEMONSTRATION, TESTING, AND INSTRUCTION REQUIREMENTS**
Operational demonstrations, system validation testing, and instruction of the District’s personnel may be performed simultaneously, subject to prior approval of the extent of consolidation in each case.
3.08  SOUND LEVEL TESTING AND WORKER PROTECTION
Measure the sound level developed by all mechanical and electrical equipment provided under the Contract Documents. Perform testing in all rooms and spaces containing such equipment during the final operation test program with all equipment operating. Use an OSHA approved instrument and record the highest sound level developed when measured according to OSHA standards in each room and space. Deliver a copy of records to the District.

3.09  IN-SERVICE CHECKS
As a part of the work, an in-service check of each system required to be validation tested shall be performed twice during the period of the Contractor's guarantee by qualified technical representatives of the various system manufacturers, including manufacturers of equipment and components within systems. Checks shall be detailed and complete, requiring not less than 8 hours at the site, and shall be performed under the observation and to the satisfaction of the District's Plant Superintendent or his designated representative. All costs for in-service checks shall be included in the Contract Price.

A.  Notification. The Plant Superintendent shall be notified in writing at least 10 days before the performance of each in-service check. The proposed dates for checking shall be changed if required by the Plant Superintendents.

B.  Consultation. At the time of each in-service check, the manufacturer's technical representatives shall consult with the Plant Superintendent to review the Operation and Maintenance Manual and the pertinent operational and maintenance problems encountered, and shall furnish technical advice and recommendations to the Plant Superintendent.

C.  Schedule. Initial in-service checks shall be performed approximately 6 months after final acceptance of the plant. The second in-service check shall be performed within 30 days of the end of the Contractor's guarantee period.

D.  Reports. A written report of each in-service check signed by the appropriate manufacturer or his representative, shall be delivered to the Plant Superintendent within 10 days following the check. The report shall describe the checking procedure in detail, and shall state all advice and recommendations given to the Plant Superintendent.

3.10  PUMPS
This article covers general stipulations applicable to the plant pumps. All applicable parts of this Section shall also apply:

A.  Equipment Testing. The purpose of equipment testing is to demonstrate that the pump units meet the specified requirements.
1. Tests shall be performed on the actual assembled unit over the entire operating range on the certified performance curve. Prototype model tests will not be acceptable.

2. All pumps 10 to 50 horsepower shall be factory-tested in accordance with the above specifications. Pumps larger than 50 horsepower may be subject to a "factory witness test" attended by a District representative. The District shall be notified at least 2 weeks in advance such that a representative can witness the pump testing. Certified test results shall be submitted to the Engineer for approval prior to shipment.

3. Pump curves shall reflect data secured during actual test runs and shall be signed by a responsible representative of the pump manufacture. Test reports and procedures shall conform to applicable requirements of the Hydraulic Institute Standards.

B. Installation. The Contractor shall install all pumping equipment in strict accordance with the manufacturer's instructions. Care shall be used in handling to avoid bumping, twisting, dropping, or otherwise damaging the equipment.

All pump manufacturers shall furnish the services of factory-trained personnel as required to examine the installation, supervise start-up of equipment installed, and repair the equipment at no additional expense to the District.

C. Field Acceptance Test. The contractor under this specification shall have full responsibility for the proper installation and performance of said pumping equipment, including furnishing the services of a pumping equipment Field Service Engineer to inspect equipment installation, and to adjust, if necessary, any portion of the pumping equipment required herein. The manufacturer’s Field Service Engineer shall assist the District in the proper conduct of pumping unit field acceptance tests. The pump units shall perform in the field as shown on the certified pump curves furnished by the Contractor. Tests shall also demonstrate operation without cavitation, vibration, overheating of moving parts, and excessive noise. The Contractor and pump manufacturer shall make necessary corrections to achieve smooth pump operation. In the event the tests reveal noncompliance of the workmanship or equipment, the Contractor shall either make alterations as necessary or replace the pumps in order to meet the requirements of the specifications at no additional cost to the District.

D. CERTIFICATION OF INSTALLATION. The Contractor shall submit a letter to the District confirming that all pumping equipment was inspected, operation checked, and installation approved in writing by the respective pumping equipment supplier.
E. **WARRANTY.** All pumping equipment shall carry an extended warranty for a two year period from the date of acceptance. All warranties shall be turned into the District prior to project completion.

F. **MAINTENANCE BOND FOR PUMPING EQUIPMENT.** The contractor or his supplier shall provide a maintenance bond (EMWD Standard form C-14 or C-14.1) from a bonding company acceptable to the District equal to 100% of the pumping equipment value (including motors, pumps and pump assemblies) for a two (2) year term starting when the District has accepted the contracted work. Equipment and/or components failing within this period due to deficiency in design, workmanship or material shall be removed, replaced, and reinstalled at no cost to the District, and said replacement shall be guaranteed for two years continuous service. The maintenance bond shall be submitted to the District prior to the performance test of the pump(s).

3.11 **EARTHQUAKE DESIGN AND RESTRAINT**

All manufacturer equipment supplied under this Contract shall be designed, constructed and attached to resist stresses produced by seismic forces specified in this Section. Equipment that does not vibrate during normal operation shall be rigidly attached. Equipment that vibrates during normal operation shall be attached by means of isolators with mechanical stops that limit movement in all directions unless it can be demonstrated by calculations that such stops are not required. Equipment or portions of equipment that move during normal operation shall be restrained with mechanical devices that prevent displacement unless it can by demonstrated by calculations that such restraints are not required.

A. **Work Included.** The work included in this Paragraph includes, but is not limited to, the following equipment items:

1. Pipe supports and hangers.
2. Electrical control panels.

B. **Minimum Earthquake Forces.** The minimum earthquake forces shall be those prescribed for Essential Facilities by the Uniform Building Code and applicable supplements as published by the International Conference of Building Officials, 5360 South Workman Mill Road, Whittier, California 90601, or as specified in the "Soil Investigation Report," whichever is greater.

Contractor shall submit shop drawings, details and data herein before specified in Section F General Conditions, F-30, "Submittals."

END OF SECTION 11005
[PAGE LEFT INTENTIONALLY BLANK]
PART 1--GENERAL

1.01 DESCRIPTION

A. SCOPE:

This Section specifies the requirements for the provision and acceptance testing for a complete and operable diesel engine driven generating system, including all devices and equipment specified herein, shown on the drawings, or required for the service. The generation system shall include the following:

1. Diesel Engine-driven generator set
2. Low exhaust emissions
3. Control system
4. Cooling system
5. Fuel supply tank
6. Generator set accessories
7. Mounting system
8. System control and testing
9. Field Testing
10. Diesel particulate filter
11. Permanently installed load bank
12. Testing with load bank

B. OPERATING REQUIREMENTS:

The electric power generating system shall have a site capability of what is shown on the contract drawings, unless specified otherwise by the manufacturer. This power will be applied for Standby operation.

1.02 QUALITY ASSURANCE

A. REFERENCES:

This paragraph references the following documents: ISO 8528 and those listed below. They are part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
B. UNIT RESPONSIBILITY:

The Contractor shall assign unit responsibility for all the diesel engine driven generating system components to the engine generator manufacturer. Engine - Generator set mounted subassemblies such as cooling system, base, air intake system, fuel system and tank, exhaust outlet fittings and equipment, and generator remote mounted controls shall also be designed, built, and assembled as a complete unit by the engine - generator manufacturer.

C. DESIGN REQUIREMENTS:

1. ENGINE:

<table>
<thead>
<tr>
<th>References</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>API Standard 670-76</td>
<td>Noncontacting Vibration and Axial Position Monitoring System with Addenda through January 1984</td>
</tr>
<tr>
<td>ASME PTC 17-1973</td>
<td>American Society of Mechanical Engineers, Reciprocating Internal Combustion Engines Performance Test Codes, 1973</td>
</tr>
<tr>
<td>NEMA MG-1-89</td>
<td>National Electrical Manufacturers Association Standards Publication Motors and Generators</td>
</tr>
<tr>
<td>NFPA 110-93 level 1</td>
<td>National Fire Protection Association Standard 110-93; Standard for Emergency and Standby Power Systems</td>
</tr>
<tr>
<td>SAE J431-79</td>
<td>Society of Automotive Engineers; Automotive Gray Iron Casting, 1979</td>
</tr>
<tr>
<td>SAE J435C-74</td>
<td>Society of Automotive Engineers; Automotive Steel</td>
</tr>
<tr>
<td>SAE J438B-70</td>
<td>Society of Automotive Engineers; Tool and Die Steels, 1970</td>
</tr>
<tr>
<td>UBC</td>
<td>Uniform Building Code</td>
</tr>
</tbody>
</table>
a. Rating - Engine brake horsepower shall be sufficient to deliver full rated generator set kW/kVA when operated at rated rpm and equipped with all engine-mounted parasitic and external loads such as radiator fans and power generators.

b. Fuel - Diesel engines shall be able to deliver rated power when operating on No. 2 diesel fuel having 35 degree API (60°F) specific gravity.

c. Fuel consumption - Diesel fuel rates shall be based on fuel having a low heating value (LHV) of 18,390 Btu/lb when used at 85°F and weighing 7.001 lb. /U.S. gal.


2. GENERATOR:

a. Voltage dip for motor starting shall not exceed 20% for any individual load step.

b. Verify the size of the specified generator based on the following parameters and the requirements above:

<table>
<thead>
<tr>
<th>STEP 1</th>
<th>HP/KVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump 1 (RVSS)</td>
<td>75</td>
</tr>
<tr>
<td>Evap. Cooler</td>
<td>7.5</td>
</tr>
<tr>
<td>Gen Rm Fan</td>
<td>2</td>
</tr>
<tr>
<td>LTG panel</td>
<td>25</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>STEP 2</th>
<th>HP/KVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump 2 (RVSS)</td>
<td>75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STEP 3</th>
<th>HP/KVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump 3 (VFD-standby)</td>
<td>0</td>
</tr>
<tr>
<td>Pump 4 (RVSS-Future)</td>
<td>75</td>
</tr>
<tr>
<td>20% Contingency</td>
<td>52</td>
</tr>
</tbody>
</table>

Total 312

3. ENGINE-GENERATOR:
a. Start time and load acceptance - Engines shall start, achieve rated voltage and frequency, and be capable of accepting load within 10 seconds when properly equipped and maintained, including block heater.

D. NOISE REQUIREMENTS AND CONTROL:

Mechanical sound level when the generator set is fully loaded shall not exceed 110 dBA when measured at a distance of 5 feet from the generator. The sound level shall not exceed 67 dBA when measured at the site property line adjacent to the residential homes.

E. MANUFACTURER’S QUALIFICATIONS

The complete power generation system, including engine, generator, exhaust system, dual wall fuel tank with leak detection, and electronic control panel, shall be the product of one manufacturer who has been regularly engaged in the production of complete generating systems for at least ten (10) years.

All components shall have been designed to achieve optimum physical and performance compatibility and prototype tested to prove integrated design capability. The complete system shall have been factory fabricated, assembled, and production tested as performed by Caterpillar or approved equal. The naming of a specific manufacturer does not waive any requirements of this specification.

The supplier shall be the engine-generating system manufacturer’s authorized local representative, who shall provide initial start-up services. The supplier shall have 24 hour service availability. The supplier shall provide factory-trained technicians who are qualified to perform trouble-shooting and repairs on the system.

F. FACTORY TESTING:

1. Functional tests. Functional testing of the complete power generation system final assembly shall be performed at the generator set manufacturer's factory to assure proper system operation. The engine generator set shall be load tested after the assembly is installed into the enclosure. Engine generator unit shall operate continuously without stoppage for a period of 8 hours. Engine generator shall operate not less than 1/2 hour at each load point at ¼, ½, ¾, and full load, and two hours at 0.8 power factor or greater. If stoppage becomes necessary during this period, the test shall be restarted from the beginning.

2. Prototype test. The system manufacturer must be able to certify that engine, generator and controls have been tested as complete systems in
accordance with NFPA 110 of representative engineering models (not on equipment sold).

G. SHIPMENT, HANDLING, AND STORAGE:

The equipment shall be protected during shipment, handling, and storage as specified in the Contract Documents.

1.03 ENVIRONMENTAL CONDITIONS

The engine-generator set manufacturer shall verify that the diesel engine is correctly sized and is capable of driving the generator with all accessories in place and operating, at the generator set kW rating after derating for the range of temperatures expected in service and the altitude of the installation.

1.04 SUBMITTALS

The following submittals shall be made in accordance with the Contract Documents.

1. Manufacturer and manufacturer’s type designation.

2. Manufacturer’s catalog and/or other data confirming conformance to specific design, material and equipment requirements including:

   Engine:
   Type, aspiration, compression ratio, and combustion cycle
   Bore, stroke, displacement, and number of cylinders
   Engine lubricating oil capacity
   Engine coolant capacity without radiator
   Engine coolant capacity with radiator
   Coolant pump external resistance (maximum)
   Coolant pump flow at maximum resistance
   EPA low exhaust emissions compliance certificate
   Exhaust Silencer
   Diesel particulate filter

   Generator: Model
   Frame
   Insulation class
   Number of leads
   Weight, total
Weight, rotor
Air flow

At rated voltage:
Efficiency at 0.8 power factor for:

<table>
<thead>
<tr>
<th>Load</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% load</td>
<td></td>
</tr>
<tr>
<td>75% load</td>
<td></td>
</tr>
<tr>
<td>100% load</td>
<td></td>
</tr>
</tbody>
</table>

Time constants, short circuit transient (T'D)
Time constants, armature short circuit (TA)
Reactance, sub-transient - direct axis (X''D),
Reactance, transient- saturated (X'D)
Reactance, synchronous - direct axis (XD)
Reactance, negative sequence (X2)
Reactance, zero sequence (X0)
Fault current, 3 phase symmetrical
Decrement curve

Radiator: Model
Type
Fan drive ratio
Coolant capacity, radiator
Coolant capacity, radiator and engine
Weight, dry
   wet

System: Dimensions:
Length
Width
Height
Weight, dry
   wet

Power rating at 0.8 power factor
kVA rating
Fuel consumption at standard conditions for:

<table>
<thead>
<tr>
<th>Load</th>
<th>Fuel Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 % load</td>
<td></td>
</tr>
<tr>
<td>75 % load</td>
<td></td>
</tr>
<tr>
<td>100% load</td>
<td></td>
</tr>
</tbody>
</table>

Combustion air inlet flow rate
Exhaust gas, flow rate
   stack temperature
Exhaust system back pressure (maximum)
Heat rejection to: coolant
   after cooler
   exhaust
   atmosphere from engine
atmosphere from generator

Load Bank KW and size

Auxiliary equipment - Specification or data sheets, including electrical equipment and controls, vibration isolators, Diesel particulate filter, and silencer.

3. Drawings - General dimensions drawings showing overall generator set measurements, mounting location, and interconnect points for load leads, fuel, exhaust, cooling and drain lines.

4. Wiring diagrams - Wiring diagrams, schematics and control panel outline drawings published by the manufacturer in Joint Industrial Council (JIC) format for controls and switchgear showing interconnected points and logic diagrams for use by contractor and owner.

5. Warranty - Written warranty from the manufacturer.

6. Service - Location and description of supplier's parts and service facility including parts inventory and number of qualified generator set service personnel.

7. Certified copies of factory test

8. Installation requirements, showing clearances required for maintenance purposes.

9. Thermal wrap. Two copies of factory documentation on the material being used shall be submitted for verify compliance with this specification.

10. Submit the generator sizing calculation per paragraph 1.02C (2)(b).

11. Operations and maintenance information in accordance with paragraph 2.14.

12. Earthquake Design Data. Submit with the shop drawings complete seismic calculations, details of construction, and method of attachment for generator set mounting to base and for anchor bolts for anchoring base to concrete slab. The calculations and details shall be signed by a Professional Engineer who has demonstrated proficiency in Structural Engineering or Civil Engineering and is registered in the State of California.
Mounting system shall be capable of withstanding earthquake forces of seismic zone 4 in accordance with the Uniform Building Code, latest edition.

1.05 SERVICE AND WARRANTY

The manufacturer shall have a local authorized dealer who can provide factory trained servicemen, the required stock of replacement parts, technical assistance, and warranty administration.

A. PROXIMITY TO JOB SITE

The manufacturer’s authorized dealer shall have a parts and service facility within 75 miles of the job site.

B. WARRANTY ADMINISTRATION

The manufacturer’s authorized dealer shall be capable of administering the manufacturer’s and dealer’s warranty for all components supplied by the selling dealer, including but not limited to the genset system, Diesel particulate Filter, and resistive load bank (who may or may not be the same as the servicing dealer).

C. WARRANTY TERMS

The manufacturer’s and dealer’s extended comprehensive warranty shall in no event be for a period of less than five years from date of initial start-up of the system or 1,500 operating hours, whichever comes first. It shall include repair parts. Labor, reasonable travel expense necessary for repairs at the job site, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair. Applicable deductible costs shall be specified in the manufacturer’s warranty. Submittals received without written warranties as specified will be rejected in their entirety.

D. WARRANTY NAMEPLATE

A warranty nameplate of not less than 6 inch by 8 inch must be affixed to the generator set with the following data:

Warranty Period:
Start-up Date:
Termination Date:
Supplier Name:
E. PARTS AVAILABILITY

The generator set supplier shall guarantee 100 percent parts availability within 48 hours from the time an order is entered with the dealer.

1.05 PERMITS

Contractor shall obtain and pay for all permits, licenses, and inspections required for electrical construction work by public agencies, utility companies having jurisdiction, and the South Coast Air Quality Management District.

AIR QUALITY PERMIT ADVISORY. Contractor shall be advised of the following potential conditions relative to securing permits to construct from the South Coast Air Quality Management District (SCAQMD). Contractor shall be solely responsible for verifying the permitting process, obtaining all permits, required emissions controls, and all other permitting issues. The following information is presented only to inform the Contractor about the potential permitting procedure and potential requirements.

- Permit(s) to construct is required from the SCAQMD before construction of a new emitting device can commence.
- Contractor shall make timely application for such permit(s).
- Contractor is responsible for scheduling but shall be advised that the SCAQMD may require up to 180 calendar days (typically 90) to issue a permit to construct after an application is filed.
- SCAQMD may require emission controls that are equivalent to “Best Available Control Technology” (BACT) and Rule 1303 Requirements for any new equipment that is not already permitted.
- SCAQMD may require stringent emission controls for new emissions units. The Contractor is advised to diligently determine the emission controls required, and to guarantee that the emission levels required by SCAQMD and the permit shall be met by the equipment provided by the Contractor.
- The Contractor is advised to consult with SCAQMD personnel to clarify all issues.
- The Contractor shall provide the permit application to EMWD for the records. EMWD shall be listed as the owner/operator on the permits associated with permitting.

PART 2--PRODUCTS

2.01 ACCEPTABLE PRODUCTS
The following equipment shall be manufacturer’s standard production model. The engine generator shall be “pre-certified/pre-approved” by AQMD for emergency power service and modified as necessary to provide the specified features and to meet specified operating conditions. The Tier rating shall be in accordance with EPA Tier Certification Requirements. There are no equals.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine-generator</td>
<td>Caterpillar, Generac, Cummins, (no equal)</td>
</tr>
<tr>
<td>Thermal Wrap</td>
<td>Advanced Thermal Products, Inc.</td>
</tr>
</tbody>
</table>

2.02 ENGINE

The engine shall be a stationary, liquid cooled, 1800 rpm, four cycle design, direct injection engine with forged steel crankshaft and connecting rods. The cylinder block shall be cast iron with replaceable wet liners and have four valves per cylinder. Design shall be not less than 6 cylinders, turbocharged and after-cooled. Engine shall not be manufactured with any Class I ozone depleting substances (ODS) as defined by Federal Register Vol. 57 No. 86.

2.03 ENGINE EQUIPMENT

The engine shall be equipped with manufacturers standard air filters, fuel filters, pressure gauges, lubricating oil cooler, filters, and pressure gauge, water pump and temperature gauge, service hour meter, flywheel, and flywheel housing when applicable.

The engine must be a certified CI engine that meets the following standards:

1. 0.15 g/bhp-hr or less PM emission standard.
2. Emission standards specified in AQMD Rule 1470 for other pollutants.

2.04 FUEL SYSTEM

A. FUEL/WATER SEPARATOR

A Raycor fuel/water separator shall be provided to protect the fuel system from water damage.

B. FUEL LINES

Flexible fuel lines between engine and fuel supply shall be provided to isolate vibration.
C. FUEL SYSTEM MAINTENANCE

The fuel transfer pump, injection pumps, rack and pinion assembly, and timing mechanism shall be maintenance and adjustment free for the life of the equipment. The fuel filter shall not require changing more frequently than once per year or every 250 hours, whichever comes first. Fuel/water separators shall not require draining more frequently than once per week.

D. REMOTE FUEL FILL STATION

Fill station shall be Pryco Inc. remote fill station or equal. Station shall include NEMA 4X dual compartment enclosure with separate electrical compartment which shall accept 120 - 240 volt AC single phase input and separate fueling compartment. Electrical compartment shall include input contacts for visual and audible alarm for 90% and 95% diesel tank fill levels. Fill system shall include 2” cam-and-groove connector, check valve and manual isolation valve. Fill compartment shall act as containment are for spills while filling and will include a lockable drain valve.

2.05 GOVERNOR

A. GENERAL

The engine governor shall control engine speed and transient load response within commercial and ISO 8528 tolerances. It shall be selected, installed, and tested by the generator set manufacturer. The Engine shall have pre-lubed pump that runs in all test and exercise modes prior to startup of motor.

B. SPEED CONTROL

The engine governor shall be an electronic speed control with 24 volt DC Electric Actuator. Speed droop shall be 0 (isochronous) from no load to full rated load. Steady state frequency regulation shall be +/-0.25%. Speed shall be sensed by a magnetic pickup off the engine flywheel ring gear. A provision for remote speed adjustment shall be included. In the event of a DC power loss, the forward acting actuator will move to the minimum fuel position.

2.06 COOLING SYSTEM

A. GENERAL

The engine jacket water cooling system shall be a closed circuit design with provision for filling, expansion, and deaeration.
The cooling pump shall be driven by the engine. Auxiliary coolant pumps required for heat exchangers or separate circuit aftercooling shall also be engine driven. The cooling system shall tolerate at least 172 kPa (25 PSI) static head. Coolant temperature shall be internally regulated to disconnect external cooling systems until operating temperature is achieved.

B. RADIATOR, ENGINE MOUNTED

Heat rejected to the engine jacket water shall be discharged to the atmosphere through a close coupled radiator. The generator set shall be installed in a noise suppressed enclosure and have a 30% antifreeze/coolant mixture. The radiator shall cool the jacket water while the engine is operating at full site capability and 0.25 H20 external air restrictions.

Additional restriction affecting air flow shall not limit the radiator's capability to adequately cool at maximum site temperature.

Air Flow Minimum Rated: Per manufacturer and adequate for Amb Cap of 125°F at connected load.

C. FAN AND BELT GUARDING

The fan, fan drive, and fan belts shall be covered with 14 gauge punched steel mesh guarding for personnel protection. The guarding shall conform to IEC 34-5, ISO and OSHA standards.

D. BLOWER FAN

The radiator cooling fan shall be a blower type driven from the engine. Air shall be drawn from the engine side and exhausted through the radiator core.

E. INLET AIR SYSTEM

The engine air cleaner shall be engine mounted with dry element requiring replacement no more frequently than 250 operating hours or once each year. If external ducting is required, maximum restriction to the combustion air inlet shall not exceed manufacturer’s requirements.

2.07 LUBRICATION SYSTEM

A. GENERAL
The engine shall be of the wet sump type, provided with a full pressure lubricating oil system arranged to distribute oil to all moving parts of the engine. The lubricating oil pump shall be of the positive displacement type and shall be gear-driven from the engine crankshaft or camshaft. The pump shall have ample capacity to circulate the amount of lubricating and cooling oil required by the engine at all operating speeds.

B. OIL FILTER

A full flow filter shall be provided. A built-in pressure relief bypass complete with pressure actuated valve and capable of conveying the maximum rate of oil flow shall be provided around each oil filter.

C. OIL COOLER

The engine shall be equipped with a lubricating oil cooler, sized to cool the oil as recommended by the manufacturer. Aftercooler water shall be circulated through the water side of the oil cooler.

2.08 EXHAUST SYSTEM

A. GENERAL

The engine exhaust system shall be installed to discharge combustion gases quickly and silently with minimum restriction. System including particulate filter and silencer shall be designed for minimum restriction, without excessive back pressure.

Stainless steel piping shall be used, with radii of 90° bends at least 1 1/2 times the pipe diameter. Piping shall be installed with 9 in minimum clearance from combustible material or incorporate appropriate insulation and shielding. Provide a stainless steel flexible connection between the engine, exhaust piping, and wall thimble. Provide isolation of dissimilar metals if/where required.

Piping shall be supported and braced to prevent weight or thermal growth being transferred to the engine and flexible expansion fittings provided to accommodate thermal growth. Support dampers and springs shall be included where necessary to isolate vibration.

Long runs of pipe shall be pitched away from the engine and water traps installed at the lowest point. Exhaust stacks shall be extended to avoid nuisance fumes and odors, and outlets to a chimney with a vent cap.
B. DIESEL PARTICULATE FILTER/SILENCER- SUPER CRITICAL(HOSPITAL)

The silencer shall provide extreme noise attenuation for environments with low background noise and slight noise emissions would be objectionable.

Standby diesel generator shall be furnished with a passive type diesel particulate filter (DPF) which shall meet the following:

1. Shall be manufactured by Johnson Matthey, Miratech, or equal.
2. Should be at least a California Air Resources Board (CARB) Level 3 Verified with a particulate matter (PM) reduction greater than 85%
3. The CARB Executive order for the DFP should either list compatibility to the generator engine family name or approval shall be granted by the AQMD.
4. Suitable for horizontal mounting with flanged inlets and outlets.
5. Filter access hatch shall be located on the side of the DPF facing towards the front or side of generator to allow accessibility and maintenance of the filters in reference to contract drawings.
6. Housing shall be stainless steel.
7. CARB verified Diagnostic Module to continuously monitor temperature and backpressure. Diagnostic Module shall have LED visual indication and dry contact customer alarms for when backpressure or Temperature exceeds normal operating conditions.
8. DPF alarm system that will work in conjunction with the Diagnostic Module to remotely alarm when cleaning of the DPF is required.
9. Diagnostic module and DPF Alarm system shall be mounted with the generator control panel. power supply and associated control and monitoring signals shall be wired to the generator control panel.
10. At a minimum the following normally open contacts shall be provided for monitoring the particulate filter:
   a. Cleaning is required
   b. High Pressure alarm
   c. High Temperature alarm
11. DPF monitors shall be provided with an Ethernet port connection to support alarm programming, trouble shooting, and downloading data.

Back pressure must not exceed 90% of engine manufacturer’s specification and shall be coordinated with other exhaust system components (e.g. DPF, silencers, piping, etc.)

C. WALL THIMBLE

A NFPA 37 and 110 compliant factory-built ventilated wall thimble rated for 1250 °F shall be provided. The wall thimble shall include rainguard and a clamp. The thimble shall be GT Exhaust System Inc., Model 20-1-1600, or equal.
D. NOISE LEVEL

Mechanical sound level when the generator set is fully loaded shall not exceed 110 dBA when measured at a distance of 5 feet from the generator. The sound level shall not exceed 67 dBA when measured at the site property line adjacent to the residential homes.

E. EMISSIONS

Generator set shall be pre-certified by the local AQMD and meet the requirements outlined in SCAQMD Rule 1470.

2.09 THERMAL WRAP

A. GENERAL

Specified thermal wrap is for the purpose of insulating the hot surfaces on generator engines for personnel and structure safety. These surfaces are: turbocharger; exhaust manifold; exhaust pipe and pipe flanges from the generator to silencer. This shall protect personnel and structure.

The thermal wrap shall consist of, but not limited to, the following materials in layers:

1. Outer fiberglass cloth.
2. One (1) inch fiberglass mat.
3. Stainless steel mesh liner on interior surface.
4. Lashing hooks.
5. Stainless steel mechanical wire for lashing.
6. Velcro strips sewn on for fastening open seam.

B. MATERIAL

Outer fiberglass cloth - The cloth shall be silicone impregnated with a specially formulated silicone rubber designed to meet rigid requirements of the Military Specification, MIL-Y-1140C. This special high temperature, flame retardant silicone rubber provides greater life and improved resistance to abrasion, flexing, tear and puncture. Silicone coated cloth is unacceptable.
1. Weight  
   34 oz/sq yd, (±10%) 

2. Thickness  
   .037 inches 

3. Tensile strength  
   Method  
   FED STD 191/5102  
   Warp  
   225 lbs/inch avg  
   Fill  
   200 lbs/inch avg 

4. Tear strength  
   Method  
   FED STD 191/5136  
   Warp  
   35# minimum average  
   Fill  
   35# minimum average 

5. Burst strength  
   Method  
   ASTM-D-774  
   Result  
   450 PSI minimum 

6. Base fabric and weave  
   Fiberglass, satin weave 

7. Color and coating  
   Silver aluminum 

8. Temperature resistance  
   -67 to 500°F 

9. Flame resistance  
   Method  
   FED STD 191-5903.2  
   Flame out  
   5 seconds  
   Afterglow  
   10 seconds  
   Char length  
   1-inch 

C. FIBERGLASS INSULATION

Fiberglass mat shall be noncombustible, nonalkaline, chemically stable, and resist corrosion. Fiberglass mat shall meet Military Specification MIL-1-16411-E and Navy certifiable MIL-1-24244. The mat blanket shall be made of long textile chopped fibers, no binders, high density and strong physical properties in applications up to 1,200°F.

1. Thermal conductivity

   300°F at 0.27 BTU/in/hr/ft sq/degree F  
   500°F at 0.41 BTU/in/hr/ft sq/degree F  
   700°F at 0.52 BTU/in/hr/ft sq/degree F 

2. Tensile strength (avg.)
Engine Generator: Diesel
11562-17

Parallel to roll 14.7 psi
Across roll 15.3 psi

3. Weight

Half (1/2) inch 6 ozs. (±10%) per sq. ft. nominal
One (1) inch 12 ozs. (±10%) per sq. ft. nominal

4. Size of fiber Average fiber diameter
0.00035 inches

5. Fusion temperature No fusion or melting at
1,300°F

6. Alkalinity Less than 0.20%

7. Stability

No physical change after being subjected to saturated steam at 225 lbs.
for 16 hours.

8. Resistance to vibration Excellent

Stainless steel mesh liner on interior surface - A woven stainless steel
mesh liner shall be sewn in as an integral interior part of the flexible and
removable thermal blanket. The mesh liner is the part of the blanket
which comes in contact with the superheated exhaust piping and
manifold.

D. EXECUTION

Exhaust piping and manifold - All edges of the thermal blanket are to be machine
stitched. Permanently mounted stainless steel hooks (binding hooks) as fasteners shall
also be fixed to edges for binding blanket edges together. This is to allow for easy
removal and replacement of the thermal blanket without destroying the blanket during
maintenance and/or repair of the engine. Stainless steel mechanical wire shall be
provided as a part of the package. Use of “hot rings” is unacceptable for binding edges
or securing blankets.

2.10 GENERATOR SYSTEM
A. **GENERATOR**

The AC generator shall be synchronous, four pole, revolving field, single pre-lubricated bearing, air cooled by a direct drive centrifugal blower fan, and directly coupled to the engine with flexible drive discs. The armature shall have skewed laminations of insulated electrical grade steel, two-thirds pitch windings. The rotor shall have amortissuer (damper) windings of layer-wound, mechanically-wedged winding construction. The rotor shall be dynamically balanced. The exciter shall be brushless, three phase, with full wave silicon diodes mounted on the rotating shaft and a surge suppressor connected in parallel with the field winding. Field discharge resistors shall not be acceptable. The regulator shall be digital. Generator shall have permanent magnet excitation power.

AC output leads shall be brought out to field connection bus bars accessible through removable plates on either side of the sheet metal output box.

Insulation system components shall meet NEMA MG1 temperature limits for a Class H insulation system. Actual temperature rise measured by resistance method shall not exceed 125 degrees Centigrade to provide additional allowance for internal hot spots. The generator and exciter insulation systems shall be suitably impregnated for operation in severe environments for resistance to sand and other air-born contaminants.

B. **EXCITER**

A permanent magnet generator (PMG) shall provide excitation power to the automatic voltage regulator for immunity from voltage distortion caused by non-linear loads on the generator. The PMG shall sustain field excitation power for optimum motor starting and shall sustain short circuit current for selective operation and coordination of system overcurrent devices.

C. **VOLTAGE REGULATOR**

The automatic voltage regulator shall be temperature compensated, digitally controlled pulse width modulated solid-state design, and include overvoltage and overcurrent protection functions. The automatic voltage regulator shall be equipped with three phase rms sensing. The regulator shall control buildup of AC generator voltage to provide a linear rise and to limit overshoot. Overvoltage protection shall sense AC generator output voltage, In the event of regulator failure or loss of reference, the regulator shall shut down its output on a sustained overvoltage of one second duration. Over excitation protection shall sense regulator output and shut down its output if overload exceeds ten seconds duration. Both overvoltage and over excitation protection shall be latched, requiring the AC generator to be stopped for reset.
Generator output voltage maintained within +/-1% of rated value for any load variation between no load and full load.

Generator output voltage drift no more than +/-0.5% of rated value at constant temperature.

Generator output voltage drift no more than +/-2% of rated value over ambient operating temperature range of 0°C to 50°C.

Telephone Influence Factor (TIF) of less than 50.

Electric Interference/Radio Frequency Interference (EMI/RFI) suppressed to commercial standards.

D. CIRCUIT BREAKER

The circuit breaker shall be mounted and connected in a guarded drip proof freestanding enclosure meeting NEMA 1, IP 22 and IEC 144 requirements. Cable lugs shall be provided for customer connections. Provide the following:

1 - Molded case circuit breaker 600 Amp frame, 3-pole, single-throw, 100% rated, stationary-mounted with manual operating handle, ground fault circuit interruption overload and short circuit trips, complete with cable lugs. Breaker shall be equipped with a 3-phase, solid state, selective trip device with adjustable long-time pickup and delay, adjustable short-time pickup and delay, and adjustable ground fault pickup and delay trip features. The breaker shall be qualified for 600 volt operation and tested in accordance with UL Standard 489.

1 - Shunt trip, 24 volt DC, on circuit breaker wired to terminal board.

3 - Current transformers, 5 ampere secondary.

1 - Ground connection point.

2.11 STARTING SYSTEM

A. GENERAL

The engine starting system shall include 24 volt DC starting motor(s), starter relay, and automatic reset circuit breaker to protect against butt engagement. Required cables will be furnished and sized to satisfy circuit requirements.
The system shall be capable of starting a properly equipped engine within 10 seconds at ambient temperatures greater than 70°F with jacket water heater.

B. WATER JACKET HEATER

Jacket water heater(s) shall be provided to maintain coolant temperature of 90°F while the engine is idle. Heaters shall be rated 1500 watts at 240 volt AC single phase power and include thermostatic controls.

C. BATTERIES

Batteries for starting and control shall be selected and supplied by the generator set manufacturer. They shall be a heavy duty SLI lead acid type with thru-partition connectors, mounted near the starting motor. Batteries shall be housed in a hard rubber or polypropylene case with provision for venting, mounted on a corrosion resistant or coated steel battery rack.

Starting batteries shall be rated 24 volt DC with a minimum of 210 ampere-hour with 1,250 cranking amps. Sizing shall consider specific application requirements of engine oil viscosity, ambient starting temperature, control voltage, overcharging and vibration.

Batteries shall be located as close to the starting motor as practical, away from spark sources, and permit easy inspection and maintenance.

The battery shall be guaranteed by the manufacturer on a pro-rated basis for 20 years and shall deliver no less than 80 percent of its rated capacity for the full 20 year warranty period.

D. ALTERNATOR

An engine mounted belt driven battery charging alternator shall be installed with an automatic voltage regulator. It shall be suitable for heavy duty applications with a rating of 24 volts, 45 amperes minimum.

E. BATTERY CHARGER

A skid mounted dual rate 10 ampere battery charger shall be provided which shall accept 120 - 240 volt AC single phase input to provide 24 volt DC output. It shall be fused on the AC input and DC output and incorporate current limiting circuitry to avoid the need for a crank disconnect relay. An AC voltage power switch shall be mounted on the face of the charger and shielded from accidental switching.
The charger shall include an AC ammeter and voltmeter, a failure malfunction alarm switch, a low battery alarm switch, and be housed in a NEMA 1 enclosure. The charger shall be rated for operation at plus 50°C ambient. Charger voltage regulator shall be temperature compensated.

2.12 FUEL STORAGE

Provide a dual wall 12-hour (full-load) sub-base fuel tank. It shall be equipped with the necessary openings including: fill, vent (extend vent to building exterior), gauges, fill and return openings. The tank shall be double wall design specifically for generator set mounting, 12 gauge steel bottom and baffles, 7 gauge top and side channel supports, and 1 inch vent fitting through the roof with flame arrester; shall be UL listed double wall construction for secondary containment with generator base tank primed and finished in enamel. Provide a remote annunciation low level switch and double wall tank leak switch for a remote alarm to the SCADA system. Provide a 90% and 95% high level alarm switch to connect to the remote fill station. Provide a high level alarm switch when the fuel level is beyond a preset level (normally 102%). Provide a red alarm light on the control panel that activates when the switch is activated.

2.13 CONTROLS

A. CONTROLS-GENERATOR

The control panel shall be designed and built by the engine-generator manufacturer. It shall be mounted with the generator and incorporate 100% solid state microprocessor based control circuitry, sealed dust tight, watertight modular components with metal housings, and digital instrumentation. The panel shall be labeled with ISO symbols and comply with IEC 144, IP 22, and NEMA 12 for external environmental resistance, and IP 44 and NEMA 12 for resistance of the internal sealed modules.

The panel shall be labeled with ISO symbols and include the following equipment: Generator AC output metering devices: Displays for volts, hertz, and amps in a single environmentally sealed module. Numeral height shall be 0.5 in. with not less than 0.5% accuracy true RMS throughout a temperature range of -40° to +70°C. Distorted generator output voltage waveform of a crest factor less than 5 shall not affect metering accuracy. Panel shall be installed so that the top of the panel shall not exceed 72” from the bottom of the sub base fuel tank/floor.

B. ENGINE MONITORING DEVICES
Display of operating hours, engine RPM, battery DC volts, oil pressure, and jacket water temperature. A momentary switch shall be provided to continuously display a selected operating parameter. The display shall annunciate fault shutdowns, cycle programming, and diagnostic codes for troubleshooting. Engine monitoring signals provided by engine mounted lubricating oil pressure and coolant temperature transducers shall be communicated over a serial data link through a Data Sending Unit (DSU) to the panel control module. The safety logic shall shut the engine down if the serial data link is lost.

Diagnostic Module and DPF alarm system shall be provided to monitor the exhaust temperature and back pressure of the diesel particulate filter (DPF). DPF monitors shall be installed on the of side of the generator control panel. Output signals from the DPF monitors shall be connected to the generator control panel for remote monitoring.

C. CONTROLS

Generator voltage level rheostat and ammeter/voltmeter phase selector switch shall be mounted on the panel door. The engine start-stop switch shall be door mounted and include positions for off/reset, run/start, stop, and automatic mode.

Start-stop logic shall have provisions for cycle cranking and cool down operation.

Shutdowns/annunciation: The generator set shall shut down and red flashing LEDs shall signal operational faults of high water temperature, low oil pressure,--over crank, and over speed.

Safety devices: ISO red emergency stop pushbutton shall be provided, and all controls, annunciation, and monitors labeled with ISO symbols.

D. CONTROL WIRING

Control wiring from the generator shall be No. 16 min AWG stranded wire, 90°C 600 VAC insulation, UL and CSA listed. Wire identification shall be located on the wire 6.35 in. from the terminal, while routing shall avoid sharp edges. Control panel ground wire shall be 12 AGW with green and yellow striped insulation rated 90øC 600 VAC UL and CSA listed. Wire shall be labeled "GND” and have a ring terminal sized for a 10-32 screw.

E. ALARM AND SHUTDOWN CONDITIONS

Indicate the following alarm and shutdown conditions; provide RESET switch to clear fault:

1. Low oil pressure  pre-alarm
2. High engine temperature  pre-alarm
3. Low engine temperature pre-alarm
4. Low fuel pre-alarm
5. Battery charger fail alarm
6. Low DC voltage alarm
7. Circuit breaker (trip or off) alarm
8. Generator overload alarm
9. Low oil pressure shutdown
10. High engine temperature shutdown
11. Low coolant level shutdown
12. Overcrank shutdown
13. Overspeed shutdown
14. Overvoltage shutdown
15. Undervoltage shutdown
16. Underfrequency shutdown
17. Spare (1) alarm or shutdown
18. DPF high pressure alarm
19. DPF high temperature alarm
20. DPF cleaning Required alarm

F. METERING

Metering shall be RMS indicating, 0.5% accuracy, digital.

1. Voltmeter
2. Ammeter
3. Frequency meter
4. Phase select switch
5. Running time

G. ALARM MODULE

A solid state microprocessor alarm module shall be included in the panel and include red and yellow flashing LEDs and silencable alarm horn to annunciate alarm conditions for low oil pressure, high water temperature, and low system DC voltage. The horn shall resound on subsequent alarms after silencing/acknowledgment, with the flashing LED displaying a solid light until the condition is corrected. It shall provide similar annunciation for remote contactors sensing low oil level, low coolant level, and one optional condition. A dry set of contacts rated at 2 amps shall be provided for remote customer monitoring of RUNNING status, TROUBLE alarm, HIGH EXHAUST BACKPRESSURE alarm, HIGH EXHAUST TEMP alarm, and CLEAN FILTER warning.
Provide a radiator mounted resistive load bank.

1. Provide load bank per the requirements of the National Fire Protection Association (NFPA) for emergency stand-by power systems.
2. Local and remote controls
3. Indicating lights: Normal operation and cooling feature
4. Branch circuit contactors each step or each 50kw circuit max
5. Full rated copper bus bar with oversized terminal junction box
7. Coordinate size of load bank with generator and DPF manufacturers. Load bank minimum size of 150kw.
8. 480v, 3-phase, 60hz

2.15 PRODUCT DATA

The following information shall be provided:

1. Certified factory test.
2. Operation and maintenance information as specified in 01430. In addition, the following:
   a. Operating instructions - with description and illustration of all indicators and engine and generator controls.
   b. Parts books - that illustrate and list all assemblies, subassemblies and components, except standard fastening hardware (nuts, bolts, washers, etc.).
   c. Preventative maintenance instructions - on the complete system that cover daily, weekly, monthly, biannual, and annual maintenance requirements and include a complete lubrication chart.
   d. Routine test procedures - for all electronic and electrical circuits and for the main AC generator.
   e. Troubleshooting chart - covering the complete generator set showing description of trouble, probable cause, and suggested remedy.
   f. Recommended spare parts list - showing all consumables anticipated to be required during routine maintenance and test.
g. Wiring diagrams and schematics - showing function of all electrical components.

All manuals and books described above shall be contained in rigid plastic pouches.

3. Installation certification Form 11000-A specified in paragraph 11562-3.

4. Training certification Form 11000-B specified in paragraph 11562-3.02.

PART 3--EXECUTION

The Generating System shall be installed and connected in accordance with manufacturer’s recommendations. Installation shall be certified on Form 11000-A as specified in Section 01999.

3.01 FIELD INSPECTION AND TESTING

A. PREDELIVERY INSPECTION

A predelivery inspection must be performed by the system manufacturers’ local dealer at the dealer’s facility to insure no damage occurred in transit and all genset components, controls, and switch gear are included as specified herein.

B. PREDELIVERY TESTING

Prior to delivery and acceptance, the generator set shall be tested to show it is free of any defects and will start automatically and carry full load. This testing shall be performed at the facility of the system manufacturer's authorized supplier.

The testing shall be done on dry type, resistive load banks capable of definite and precise incremental loading. Salt water brine tanks or load banks requiring water as a source of cooling will not be allowed.

The load banks shall not be dependent on the generator control instruments to read amperage and voltage on each phase. Rather, the test instrumentation will serve as a check of the generator set meters.

Load bank testing shall be done in the presence of the Owner's Construction Manager or his appointed representative. Testing shall be for a minimum of two (2) hours under full load.
All consumables necessary for testing shall be furnished by the bidder. Any defects which become evident during the test shall be corrected by the bidder at no additional cost to the District prior to shipment to the job site.

C. PREDELIVERY TESTING PROCEDURE

A "start and test" shall be performed by factory trained technicians. All test equipment, facilities and personnel shall be provided by the supplier. Owner representatives shall be invited to witness all tests. The test shall be performed on the complete fabricated generator set within sound attenuated enclosure.

1. Check all electrical exhaust, fuel and water connections for proper size, continuity and tightness of fittings. Check out all fluids for appropriate levels. Check jacket water heater if operational. Start-up engine and make an initial start-up check of all operational equipment. Upon completion of initial start-up and system checkout, the supplier of the generator set shall perform a field test, with the Construction Manager notified in advance, to demonstrate load carrying capability, stability, voltage and frequency.

2. Connect a load bank equivalent to at least 100 percent of the nameplate rating at unity power factor.

3. The generator set shall be run for 1 1/2 hours during first initial run for proper engine break-in, (1/2-hour no-load, 1/2-hour at 50 percent rated load, 1/2-hour at 75 percent load) then 100 percent for 2 hours. The test period shall extend until oil and water temperatures have stabilized for a period not less than 30 minutes. Records shall be maintained throughout this period at fifteen minute intervals to record water temperature, fuel pressure, oil pressure, ambient air temperature, voltage, amperage, frequency, kilowatts and power factor.

4. Test all safety devices using methods recommended by the manufacturer.

5. Test results shall be documented and forwarded for approval.

6. There shall be a 10-minute unloaded run at the conclusion of the test to allow engine to cool before shutdown.

D. POST-INSTALLATION TESTING
Following installation, the following tests shall be performed by the system manufacturer's qualified representative(s) in the presence of the owner's representative.

Prestart Checks:

- Oil level
- Water level
- Day tank fuel level
- Battery connection and charge condition
- Engine to control interconnects
- Engine generator intake/exhaust obstructions
- Engine room ventilation obstructions
- Removal of all packing materials

E. FIELD TEST

The Contractor shall provide all fuel for the tests. After the tests are complete the Contractor shall fill the fuel storage tank to 100% full. A "start and test" shall be performed by factory trained technicians. All test equipment, facilities and personnel shall be provided by the supplier. Owner representatives shall be invited to witness the following tests(s). There is a high school about 0.5 miles away from the pump station. Field testing shall not take place when school is in session. All field start-up and operational testing shall take place on the weekend, or outside the school day hours of 7:30 am to 3:30 pm on week days that school is in session.

1. Check all electrical exhaust, fuel and water connections for proper size, continuity and tightness of fittings. Check out all fluids for appropriate levels. Check jacket water heater if operational. Start-up engine and make an initial start-up check of all operational equipment. Upon completion of initial start-up and system checkout, perform a field test, with the Owner notified in advance, to demonstrate load carrying capability, stability, voltage and frequency.

2. The generator set shall be run for 1-hour during first initial run for proper engine break-in. Records shall be maintained throughout this period at five minute intervals to record water temperature, fuel pressure, oil pressure, ambient air temperature, voltage, amperage, frequency, kilowatts, and power factor. Testing shall meet requirements.

3. Return to normal power source.
4. With prime mover in "Remote Start" condition and utilizing the building load, simulate failure of the normal power source by opening all breakers and switches.

5. Run the generator for one (1) hour running the intended site load; the test period shall extend until oil and water temperatures have stabilized for a period not less than 30 minutes. Observe occurrences and record readings every fifteen (15) minutes as in 2 above.

6. Test all safety devices using methods recommended by the manufacturer.

7. Measure noise level at the middle and both ends of the two residential wall segments.

8. There shall be a 10-minute unloaded run at the conclusion of the test to allow engine to cool before shutdown.

12. Test results shall be documented and submitted for approval.

13. Non-emergency generator start-up or operation will NOT be allowed from 7:30 am to 3:30 pm on days school is in session.

3.02 TRAINING

The Contractor shall cause the generating system manufacturer, as part of the commissioning services, to provide not less than 16 hours of on-the-job training. Training shall include the requirements of Section 01664 and the following:

1. Diesel Engine theory
2. AC Generator theory
3. General operational information for the specific equipment provided under this section.
4. Troubleshooting.
5. Operation of the equipment in automatic and manual modes.
6. Routine maintenance.

Training shall be certified on Form 11000-B as specified in Section 01999.

END OF SECTION 11562
SPECIFICATIONS - DETAILED PROVISIONS
Section 11936 - Vertical Turbine Pumps

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ATTACHMENT
MANUFACTURER’S CERTIFICATE OF PROPER INSTALLATION
PART 1 - GENERAL

1.01 GENERAL
This Specification is for close-coupled vertical turbine pumps for applications in sumps or suction cans, including discharge head, column, shaft, bowl assembly, vortex suppressor, lubrication system, and, if applicable, suction can. All equipment furnished under this section shall be new and of current manufacture and shall be guaranteed free from defects in material, design, or workmanship. All parts of the pump exposed to water shall be of stainless steel, brass, heavy cast iron, or equivalent corrosion-proof material. Unless otherwise specified herein, all applicable provisions of ANSI/AWWA E-101, Part A, latest edition, for Vertical Turbine Pumps, are hereby made a part of these Specifications. The pumps shall be manufactured by Peerless, Goulds, Floway or District approved equal.

Refer to the Special Conditions for additional requirements/information.

1.02 UNIT RESPONSIBILITY
All combinations of manufactured equipment which are approved under this specification shall be entirely compatible and the Contractor and the listed manufacturer shall be responsible for the compatible and successful operation of the various components of the units conforming to the specified requirements. All necessary mountings, couplings, and appurtenances shall be included with each unit. All materials employed in the pump equipment shall be suitable for the intended application and shall be high grade commercial quality, free from all defects and imperfections that might affect the serviceability of the product for the purpose for which it is intended.

Should the equipment selected by the Contractor require revisions to the structures, piping, electrical, or other work shown on the drawings, the Contractor shall include the cost of such revisions in his bid for the equipment, and no extra payment shall be made for such revisions. All such revisions shall be submitted for District approval, and shall be subject to the approval of the Engineer.

1.03 SUBMITTALS
Submittals shall be provided to the Engineer for approval prior to beginning manufacture/construction of the pumping units in accordance with the General Conditions. Submittals shall include:

A. Shop Drawings including the following information:

1. Pump name and identification number.

2. Pumping unit outline diagrams.

4. Electrical data including control and wiring diagrams.

5. Assembly and installation drawings including shaft size, coupling anchor bolt plan, part nomenclature, materials list, outline, dimensions, and shipping weight.

B. Certified Pump Curves showing head versus capacity, bowl efficiency versus capacity; NPSH and BHP requirements, and thrust and moment of inertia characteristics. Each curve shall be continuous over the full operating range from zero (0) flow up to the maximum flow permissible through each pump, and shall be based upon the RPM listed. Each curve shall state the RPM speed of the pumping unit, and shall be furnished full-size on 8-1/2" x 11" paper. The Contractor shall provide pumps capable of meeting all aspects of the Detailed Vertical Turbine Pump Specification section and as shown on the Drawings.

C. Operation & Maintenance Manuals. Sets of printed instructions relating to proper maintenance and parts lists indicating the various parts by name, number and diagram where necessary shall be furnished in duplicate with each unit or set of identical units as required by the General and/or Special Conditions. Recommended spare parts lists shall be included and local supplier's name where spare parts are available.

1.04 OPERATING CONDITIONS

The capacities, heads, efficiencies, and horsepower requirements are for completely assembled units and are specified in the Detailed Vertical Turbine Pump Specification section. Each pumping unit shall meet the requirements and design points as specified therein.

Each pump and motor combination shall be matched to deliver at least the maximum flow rate at the rated speed without entering into the motor’s service factor. Motors shall meet the requirements of Section 16150 and shall be the "hollowshaft" type.

The units shall be capable of withstanding a complete flow reversal (backspinning) without damage to the pump, motor, bowls, or line shaft.
2.01 PUMP CONSTRUCTION

A. Pump Bowls. The bowls shall be of close-grained, gray cast iron, Class 30 or better, precision cast, free from blow holes, sand pockets, and other detrimental defects. The water passageways in said bowls shall be smooth so as to allow freedom from cavitation and permit maximum efficiency. For pumps with totally enclosed impellers, (all pumps less than 75 B.H.P.), each bowl shall have a rubber or bronze lateral seal ring and a side seal to prevent slippage of water between bowl and impeller. In order to improve the guaranteed efficiency of the design point(s), lined bowls shall be furnished. Said lining, vitreous porcelain enamel or equal, shall be of such material and applied in such manner to produce a long effective life which shall not be applied for the purpose of a short time gain in efficiency. Lining, identical to that furnished hereunder, shall have been used in the field, under identical conditions, with satisfactory results for a least a five-year period. The outside diameter of the bowls shall be of such size to fit the suction can I.D., with proper clearances. The bowls shall be able to withstand a minimum of 1-1/2 times the maximum pump shut-off head (zero GPM) pressure or twice the pressure at rated capacity, whichever is greater. In no case shall the pressure rating of the bowl be less than 300 psi. Bowl material shall have a minimum tensile strength of 30,000 psi.

B. Pump Impellers. Impellers for pumps less than 75 B.H.P. shall be the totally enclosed type. For applications of 75 B.H.P. or greater, impellers may be either the totally enclosed or semi-open type unless otherwise specified in the Detailed Vertical Turbine Pump Specification section. The impellers shall be of the enclosed or semi-open type, constructed of SAE 40 or 64 bronze. They shall be balanced hydraulically and dynamically to prevent vibration and shall be smoothly finished on all surfaces to reduce friction losses to a minimum. The impellers shall be accurately fitted and securely locked to the pump shaft and vertical adjustment of the impellers shall be possible by means of an adjustment method in the driver assembly.

C. Impeller Lock Collets. The lock collets shall be constructed of AISI-B-1113 steel or stainless steel.

D. Pump Shaft. The pump shaft shall be constructed of AISI-416 stainless steel and shall be accurately machined to a sufficient dimension to provide smooth operation and to easily withstand torsional loads and other stresses encountered within the pump. The pump shaft shall have adequate bearing support at every bowl section and at the top and bottom case section, and shall be equipped with a suitable steel coupling for connection to the line shaft.
Vertical Turbine Pumps
Section 11936 – 4

E. **Pump Bearings.** The suction case section and the discharge case section shall be sleeve type constructed of SAE 64 bronze. The bowl bearings shall be sleeve type of zinc-free bronze, or equal as approved by the engineer. Bearing area, bearing cooling, and bearing lubrication shall be ample for long trouble-free operating life of the equipment.

F. **Pump Discharge Case.** The discharge case shall securely fasten the top pump bowl assembly to the column piping. This section shall be heavily reinforced with streamlined fluid passages and shall contain bearings for the pump shaft.

G. **Pump Suction Case.** The suction case shall securely fasten the bottom bowl assembly to the suction bell. This section shall be heavily reinforced with streamlined fluid passages and shall contain a sleeve bearing for the pump shaft.

H. **Pump Suction Bell.** A suction bell constructed of Class 30 cast iron shall be provided, with entrance vanes so designed to allow even flow of water in the pump. The suction bell shall have an inlet area of at least four times the eye area of the impeller supplied.

I. **Pipe Column Nipple.** The column nipple shall be standard steel pipe and shall conform to the following diameter weight per foot table:

<table>
<thead>
<tr>
<th>Nominal Size (inches)</th>
<th>O.D. (inches)</th>
<th>Weight per Foot (pounds)</th>
<th>Fitting</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4.500</td>
<td>10.79</td>
<td>Threaded or flanged</td>
</tr>
<tr>
<td>6</td>
<td>6.625</td>
<td>18.97</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>8</td>
<td>8.625</td>
<td>28.55</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>10</td>
<td>10.750</td>
<td>40.48</td>
<td>Flanged only</td>
</tr>
<tr>
<td>12</td>
<td>12.750</td>
<td>49.58</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>14</td>
<td>14.000</td>
<td>54.57</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>16</td>
<td>16.000</td>
<td>62.58</td>
<td>&quot; &quot;</td>
</tr>
</tbody>
</table>

For columns 8" in diameter and smaller, the column may be threaded. For diameters 10" and larger, the column shall be a flanged assembly. The ends of the pipe section shall be faced parallel and machined with threads and/or flanged to insure proper alignment when assembled. The exterior and interior surfaces of all column pipe shall be cleaned, primed, and lined with high build epoxy, or approved equal, with application procedures per paint and manufacturer’s published instructions. The minimum thickness shall be 10 mils applied in no less than three (3) coats.
J. **Pump Discharge Head Assembly.** The pump discharge head shall be of fabricated steel or close grained, cast iron, ASTMA48 Class 30. Unless specifically shown on the construction drawings, the pump supplier shall be responsible for determining the type of discharge head to be used for the given application. Cast iron discharge heads shall be free of sand holes and other defects, accurately machined and with a surface discharge. Discharge shall be machined and drilled to ANSI standards for 125# rating and shall be of the diameter shown on the construction drawings. The top of the discharge head shall have a rabbet fit to accurately locate the vertical hollow shaft driver, and have a diameter equal to the driver base diameter (BD).

A shaft mechanical seal assembly of silicon carbide steel shall be provided, including permanent seal housing with renewable internals (faces and springs, etc.).

The seal assembly shall be approved by the Engineer and shall be manufactured by Chesterton, No. 155 or approved equal; specifically selected for the fluid being pumped at shut-off head pressure.

K. **Pump Line Shaft Assembly.** A line shaft shall be supplied, of ASTM A276, Type 416 material, or equal as approved by the Engineer, and shall conform to AWWA E-101, Section A4.3 and A5.5.

L. **Pump Nameplate.** The pump shall be supplied with an easy-to-read, corrosion resistant nameplate. It shall contain complete pump information including: pump manufacturer's name, serial number, pump model number, number of stages, speed, T.D.H. and capacity in GPM at the middle design point, year manufactured, etc. Said nameplate shall be mounted on the pump head.

M. **Watertight Seal.** There shall be an appropriate full-face gasket installed between the suction can flange and the pump discharge head assembly to insure and provide a watertight seal.

N. **Vortex Suppressor.** A stainless steel vortex suppressor, as manufactured by Peerless Pump Company or approved equal, shall be provided and attached to the suction bell of the pump in order to prevent excessive turbulence in the water as it passes from the suction inlet pipe into the suction can, down between the bowl assembly and the suction can, and into the suction bell of the pump.

O. **Thrust Bearings.** Upthrust loads encountered in normal service, including start-up, shall be accommodated by suitable thrust bearings in the pump and/or motor assembly.

P. **Coupling.** The pump/hollowshaft motor coupling shall be, type 416 stainless steel and shall be capable of transmitting the total torque of the unit in either direction.
2.02 SUCTION CAN
(Applicable where required by Drawings or Special Conditions)

A. **Size.** Suction cans shall be sized as shown on the Drawings unless a larger diameter or length is recommended by the pump manufacturer. As a minimum, suction cans shall be of sufficient size to accept a pump with a one inch larger diameter bowl (note this does not refer to impeller trim) and one additional stage. The can inside diameter shall be adequate to accommodate the column pipe flanges, and where applicable, provide adequate clearance for flow around flanges (i.e. tee head pumps).

B. **Materials & Fabrication.** Suction cans shall be equipped with an adequately sized steel base plate, welded to top of can, designed for attachment of the pump discharge head. Suction can, including suction inlet pipe, shall be cement mortar lined by centrifugal application, in accordance with accepted manufacturing standards. Suction can coating shall be one (1) shop applied coat of damp-proof red primer (SO), refer to "Protective Coating for Water Pumping Plants," System P1, Section 09871.

2.03 PUMP REQUIREMENTS - GENERAL

A. **Pressure Gauges.** Pressure gauges shall be installed on all pump discharge lines and, where applicable, on the pump suction via a port in the discharge head or suction can baseplate. The pressure gauges shall be 4” diameter and accurate to one-half percent of full-scale.

B. **Suction Can Air Release Valve (where applicable).** A one (1) inch air release valve shall be installed on the discharge head or suction can baseplate for the purpose of venting accumulated air in the suction can. The valve shall be Model 50 as manufactured by APCO or approved equal.

PART 3 - EXECUTION

3.01 PUMPING UNIT - PUMP SUPPLIER REQUIREMENTS
Pump supplier shall have complete office/shop facilities located within 100 miles of the job site, and shall have a 10 years minimum successful experience record for pump sales/service.

3.02 DELIVERY
The Contractor shall order the pump at the earliest possible time to allow time for the preparation, submittal, approval of shop drawings, and subsequent manufacture and installation of the pump in a timely manner.
3.03 PREPARATION
Sets of instructions for field procedures for erection, adjustments, inspection, and testing shall be provided prior to installation of the pumps, as required by the General or Special Conditions.

3.04 EQUIPMENT TESTING
The purpose of equipment testing is to demonstrate that the pump units meet the specified requirements.

A. Tests shall be performed on the actual assembled unit over the entire operating range on the certified performance curve. Prototype model tests will not be acceptable.

B. All pumps 10 to 50 horsepower shall be factory-tested in accordance with the above specifications. Pumps larger than 50 horsepower may be subject to a "factory witness test" attended by a District representative. The District shall be notified at least 2 weeks in advance such that a representative can witness the pump testing. Certified test results shall be submitted to the Engineer for approval prior to shipment.

C. Pump curves shall reflect data secured during actual test runs and shall be signed by a responsible representative of the pump manufacture. Test reports and procedures shall conform to applicable requirements of the Hydraulic Institute Standards

3.05 INSTALLATION
The Contractor shall install all pumping equipment in strict accordance with the manufacturer's instructions. Care shall be used in handling to avoid bumping, twisting, dropping, or otherwise damaging the equipment.

All pump manufacturers shall furnish the services of factory-trained personnel as required to examine the installation, supervise start-up of equipment installed, and repair the equipment at no additional expense to the District.

3.06 FIELD ACCEPTANCE TEST
The contractor under this specification shall have full responsibility for the proper installation and performance of said pumping equipment, including furnishing the services of a pumping equipment Field Service Engineer to inspect equipment installation, and to adjust, if necessary, any portion of the pumping equipment required herein. The manufacturer’s Field Service Engineer shall assist the District in the proper conduct of pumping unit field acceptance tests. The pump units shall perform in the field as shown on the certified pump curves furnished by the Contractor. Tests shall also demonstrate operation without cavitation, vibration, overheating of moving parts, and excessive noise. The Contractor and pump manufacturer shall make necessary corrections to achieve smooth pump operation. In the event the tests reveal noncompliance of the workmanship or equipment, the Contractor shall either make alterations as necessary or replace the pumps in order to meet the requirements of the specifications at no additional cost to the District.
3.07 CERTIFICATION OF INSTALLATION
The Contractor shall submit the attached “Manufacturer’s Certificate of Proper Installation” to the District confirming that all pumping equipment was inspected, operation checked, and installation approved in writing by the respective pumping equipment supplier.

3.08 WARRANTY
All pumping equipment shall carry an extended warranty for a two year period from the date of acceptance. All warranties shall be turned into the District prior to project completion.

3.09 MAINTENANCE BOND FOR PUMPING EQUIPMENT
The contractor or supplier shall provide a maintenance bond (see EMWD standard form C-14 or C-14.1) from a bonding company acceptable to the District equal to 100% of the pumping equipment value (including motors, pumps and pump assemblies) for a two (2) year term starting when the District has accepted the contracted work. Equipment and/or components failing within this period due to deficiency in design, workmanship or material shall be removed, replaced, and reinstalled at no cost to the District, and said replacement shall be guaranteed for two years continuous service. The maintenance bond shall be submitted to the District prior to the performance test of the pump(s).

END OF SECTION 11936
MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION

OWNER: ___________________________ EQPT SERIAL NO: ___________________________

EQUPT TAG NO: ___________________________ EQPT/SYSTEM: ___________________________

PROJECT NO: ___________________________ SPEC. SECTION: ___________________________

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

(Check Applicable)

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

Comments: ________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

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

Date: ___________________________

Manufacturer: ________________________________________________________________

By Manufacturer’s Authorized Representative: ___________________________

(Authorized Signature)
PART 1--GENERAL

1.1 OPERATING CONDITIONS

A. PERFORMANCE REQUIREMENTS:

Operating Condition

Condition A^{1,4}

| Capacity, gpm | 1958 |
| Total head, feet | 118 |
| NPSHA, feet | 99 |

Condition B^{2,4}

| Capacity, mgd | from pump H/Q curve |
| Total head, feet | 87 |
| NPSHA, feet | 79 |

Condition C^{3,4}

| Capacity, mgd | from pump H/Q curve |
| Total head, feet | 140 |
| NPSHA, feet | 117 |

NOTES:

1. Condition A shall be taken as the rated, continuous-duty operating condition. Performance at the rated condition shall be guaranteed. Condition A has been selected to obtain the rated pumping capacity for the installation. It is not intended that the pumps be selected for maximum efficiency at Condition A. Pumps furnished under this section should be selected to achieve Condition A performance, but also operate continuously without objectionable vibration or cavitation at the head specified under Conditions B & C. Condition A shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer’s published application data for the specific model proposed for this application.
2. Condition B head is presented to indicate operating conditions when the pump is operating against minimum anticipated system head, assuming a hypothetical head-capacity curve. Condition B shall be used for pump selection. Condition B shall be located preferably within the Preferred Operating Region or at least within the Allowable Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer’s published application data for the specific model proposed for this application. NPSHA, as listed for Condition B is calculated on a pumped flow of 2400 gpm.

3. Condition C is the anticipated continuous duty maximum head condition. Pumps furnished under this specification shall be capable of sustained (24 hours per day) operation at this condition. Condition C shall be located preferably within the Preferred Operating Region or at least within the Allowable Operating Range as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer’s published application data for the specific model proposed for this application.

4. Total head in the above tabulation is the algebraic difference between the discharge head and suction head as defined in ANSI/HI 2.1 – 2.6 and are exclusive of pump intake, bowl, discharge column, discharge head and lineshaft losses. A curve showing these losses separately shall be provided as a part of the submittal information. Net positive suction head available (NPSHA) in the above tabulation is referenced to project elevation 1759 and is calculated in accordance with ANSI/HI 2.3 for average barometric pressure and maximum temperature conditions. Calculated NPSHA has been reduced by two feet as an allowance for uncertainties associated with the pumped fluid and sump conditions, and no reduction in NPSH margin limitations will be permissible due to the inclusion of this allowance. NPSHA at the pump impeller eye can be determined by adjusting the given value in the above tabulation by proposed pump dimensions and the indicated requirements for pump installation details.

B. DESIGN REQUIREMENTS:

Equipment provided under this section shall conform to the following:

**Pump**

- Minimum peak efficiency, percent\(^a\)
  - Pump: 78

- Impeller type: Enclosed

- Piping connection size, inches, minimum
Discharge 10
Minimum bell diameter, inches\(^b\) 14

Operating speed, rpm, maximum 1780

Motor horsepower, maximum 75

**Pump Can**

Pump Can minimum inside diameter 20-inches

Pump Can inside finish Cement Mortar lining (see Detail 1/M5)

**NOTES:**

\(^a\) The minimum peak efficiency shall not be less than shown, but is not required to coincide with any specified operating condition in this section. Pump efficiency shall be within 2 percent of bowl efficiency when calculated at the point of peak bowl efficiency on the pump’s head/capacity curve.

\(^b\) Suction bell inlet velocities shall not exceed the recommended 5.5 feet/sec per HI 9.8 at Condition B. Pump suction can barrel shall be sized so that the max velocity does not exceed 5 feet/sec between the can and bell, flange or coupling per HI 9.8 at Condition B.

**PART 2--PRODUCTS**

2.1 **CORROSION PROTECTION:**

The pump discharge column, discharge head, bowl assembly, and pump can shall be lined and with holiday free fusion bonded epoxy Scotchkote 134 or approved equal. Thickness of the lining shall be 12 mils.

2.2 **SPARE PARTS**

For each unit consisting of one or two pumps of like size and service furnished under this section, one set of the following spare parts shall be furnished. Two sets shall be furnished for each unit consisting of more than two pumps of like size and service.

1 - suction bell/manifold bearing assembly
1 - set bowl bearings
1 - lineshaft bearing assembly
1 - set wear rings
1 – shaft seal, complete

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PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Valve and gate operators, handwheel operators, bench stands, floor stands, accessory equipment and floor boxes, and key operated valves.

1.02 REFERENCES

A. Aluminum Association (AA):

1. DAF-45 - Designation System for Aluminum Finishes.

1.03 SUBMITTALS

A. Shop Drawings: Include shop drawings for hydraulic gate lifts with shop drawings for gates as integrated units.

1.04 QUALITY ASSURANCE

A. Provide valve operators integral with valve or gate, except for T-wrenches or keys, and portable operators intended to operate more than 1 valve.

B. Provide similar operators by 1 manufacturer.

C. Provide gates and hand operating lifts by 1 manufacturer.

D. Provide hydraulic gate lifts by 1 manufacturer.

E. Provide hydraulic valve operators and motorized operators by 1 manufacturer.

1.05 MAINTENANCE

A. Extra Materials:

1. Key Operated Valve Keys or Wrenches:
a) Furnish a minimum 4 keys with 4 foot shafts and 3 foot pipe handles or wrenches with 4 foot shafts and 3 foot handles for operating key operated valves.

**PART 2 - PRODUCTS**

2.01 MATERIALS

A. Valve and Gate Operators:

1. Stem Covers: Aluminum pipe; threaded cap on top; bolted aluminum flange on bottom; 1 by 12 inch slots cut at 18 inches on center in front and back of pipe; capable of covering threaded portion of greased stems that project above operators when gates or valves are opened or closed.

2. Stem Cover Flanges, Pipes and Caps: Etched and anodized to produce chemical finishes in accordance with AA C 22, medium matte finish, and AA A 41 clear anodic coating, or described in AA publication 45, after fabrication.

3. Gate Stem Covers: Concentric with stem.

4. Position Indicators: Tail rods on hydraulic cylinders, or dial indicators with clear full-open and closed position indicators, calibrated in number of turns or percentage of opening.

5. Manual or Power Operator Size: Sized to deliver maximum force required under most severe specified operating condition, including static and dynamic forces, seat and wedge friction, and seating and unseating forces with safety factor of 5, unless otherwise specified.

6. Operator Size: Capable of supporting weight of suspended shafting unless carried by bottom thrust bearings; shaft guides with wall mounting brackets.

7. Provisions for Alternate Operation: Where specified or indicated on the Drawings, position and equip crank or handwheel operated geared valve operators or lifts for alternate operation with tripod mounted portable gate operators.

8. Operation: Counterclockwise to open with suitable and adequate stops, capable of resisting at least twice normal operating force to prevent overrun of valve or gate in open or closed position.

9. Open Direction Indicator: Cast arrow and legend indicating direction to rotate operator on handwheel, chain wheel rim, crank, or other prominent place.
10. **Buried Operator Housing:** Oil and watertight, specifically designed for buried service, factory packed with suitable grease, completely enclosed space between operator housing and valve body so that no moving parts are exposed to soil; provide operators with 2 inch square AWWA operating nut.

11. **Worm Gear Operators:** Provide gearing on worm gear operators that is self-locking with gear ratio such that torque in excess of 160 foot-pounds will not need to be applied to operate valve at most adverse conditions for which valve is designed.

12. **Traveling Nut Operators:** Capable of requiring maximum 100 foot-pounds of torque when operating valve under most adverse condition; limit stops on input shaft of manual operators for fully open and closed positions; non-moving vertical axis of operating nut when opening or closing valve.

**B. Handwheel Operators:**

1. **Manufacturers:** One of the following or equal:
   a) Rodney Hunt Company.
   b) Waterman Industries, Incorporated.
   c) H. Fontaine.

2. **Mounting:** Floor stand or bench stand.

3. **Bearings above and below Finished Threaded Bronze Operating Nut:** Ball or roller.

4. **Wheel Diameter:** Minimum 24 inch.

5. **Indicator:** Counterclockwise opening with arrow, and word OPEN cast on top of handwheel indicating direction for opening.

6. **Pull to Operate:** Maximum 40 pounds pull at most adverse design condition.

7. **Stem Travel Limiting Device:** Setscrew locked stop nuts above and below lift nut.

8. **Grease Fittings:** Suitable for lubrication of bearings.

**C. Hand-cranked Geared Operators:**

1. **Type:** Single removable crank; fully enclosed.


5. Teeth on Gears, Spur Pinions, Bevel Gears, and Bevel Pinions: Cut.


8. Bearings above and below Flange on Lift Nuts: Ball or roller; capable of taking thrust developed by opening and closing of gates under maximum operating head; with bronze sleeve bearings and sufficient grease fittings for lubrication of moving parts, including bearings and gears.

9. Crank Rotation Indicator: Cast arrow with word OPEN in prominent location readily visible indicating correct rotation of crank to open gate.

10. Hand Cranks: 15 inch radius; requiring maximum 25 pounds pull to operate gate at maximum operating head; with:
    a) Revolving brass sleeves.
    b) Gears, spur pinions, bevel gears, and bevel pinions with cut teeth.
    c) Cast manganese bronze lift nuts.
    d) Cast-iron lift parts with smooth exterior surfaces.

11. Indicator: Dial position type mounted on gear operator; enclosed in cast-iron or aluminum housing with clear plastic cover; marked with fully open, 3/4, □, 1/4, and closed positions.

D. Floor Boxes:

1. Manufacturers: One of the following or equal:
   a) Waterman industries, Inc.
   b) ________________________________
2. Floor Boxes: Cast-iron; with:
   a) Counter type indicator.
   b) Hinged, lockable lid with directional arrow.
   c) 2 inch square AWWA operating nut.

E. Floor Stands:

1. Manufacturers: One of the following or equal:
   a) Rodney Hunt Company.
   b) Waterman industries, Inc.
   c) H. Fontaine.

2. Floor Stand Assemblies: Heavy-duty cast-iron, suitable for mounting specified operator.

F. Bench Stands:

1. Bench Stands: Handwheel operators or hand crank, geared operators conforming to hand-cranked geared operator requirements, except capacity to be mounted on haunch, wall bracket, or self-contained gate yoke.

G. Accessory Equipment:

1. Wall Brackets or Haunches: As indicated on the Drawings.

2. Stems: Stainless steel; sized to match output of operator; minimum gate or valve operating stem diameter; maximum 200 slenderness ratio.

3. Stem Couplings: Stainless steel; internally threaded to match stem; lockable to stem by set screw.

4. Stem Guides: Cast-iron with silicon bronze bushing; maximum 200 slenderness ratio; capable of being mounted with wall bracket; adjustable in 2 directions.

5. Wall Brackets: Cast-iron, capable of withstanding output of operator, adjustable in 2 directions.

6. Stem Stuffing Boxes: Cast-iron, with adjustable gland and packing.

8. Geared Valve Operators: Provided with cut gears, either spur or worm; sized to operate valves at most adverse design condition; with maximum 40 pound pull at handwheel or chain wheel rim.


10. Accessory Equipment for Valves and Gates Requiring Remote Operators: Operating stems, stem couplings, stem guides, wall brackets, and stem stuffing boxes.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install floor boxes in concrete floor with lid flush with floor.

B. After installation of gate and stem covers, mark stem covers at point where top of stems are at full-open position and at closed position.

C. Attach floor stand to structure with anchor bolts

D. Install stem stuffing boxes where operating stems pass through intermediate concrete floor slabs.

3.02 SCHEDULES

A. Provide Geared Operators for Following Valves:

   1. Butterfly valves larger than 6 inches, nominal size, on liquid service.
   2. Butterfly valves larger than 10 inches, nominal size, on gas and air service.
   3. Plug valves 6 inches, nominal size, and larger.

B. Provide handwheel operators for valves mounted 6 feet or less above floors.

C. Provide chain wheel operators for valves mounted more than 6 feet to center line above floors.

END OF SECTION 13446
SPECIFICATIONS - DETAILED PROVISIONS
Section 15058 - Cast Iron Fittings

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PART 1 - REQUIREMENT

1.01 CAST IRON FITTINGS

A. Cast iron flanged fittings shall conform to the latest revision of ASA Spec. A-21.10 (AWWA C-110) flanged fittings. These fittings shall be cement lined in accordance with the latest revision of ASA Spec. A21.4 and shall have standard machine finish.

B. Cast iron hub fittings shall conform to the latest revision of AWWA C100-52 ASA 21-10-250 p.s.i. for Class 150 and 200 pipe, designed for use with pressure pipe except as otherwise specifically stated elsewhere. These fittings shall be cement lined in accordance with the latest revision of ASA Spec. A21.4.

Size, joint type, and pressure rating (150 or 250 p.s.i.) shall be as specified on purchase order or shown on construction plans and bid sheet.

END OF SECTION 15058
SPECIFICATIONS - DETAILED PROVISIONS
Section 15059 - Welded Steel Fittings

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PART 1 - REQUIREMENT

1.01 FITTINGS
Fittings shall be fabricated as shown on the contract drawings, and/or as specified in the Special Conditions.

1.02 FLANGES

A. Steel flanges shall conform to the requirements of Drawing B-288 made a part hereof by reference.

B. Ring flanges shall be for welding to the pipe unless otherwise noted on the plans.

C. Screwed flanges, where required, shall be Crane No. 556 or approved equal.

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PART 1 - GENERAL

1.01 DESCRIPTION
Contractor to furnish steel pipe as hereinafter described.

A. Types of Steel Pipe
   1. Cement mortar lined and cement mortar coated steel pipe (CML&C). This type of pipe is to be used in steel pipeline construction unless otherwise specified.
   2. Pre-tensioned concrete cylinder pipe.
   3. Cement mortar lined and coal-tar enamel coated and wrapped steel pipe.
   4. Cement mortar lined and asphalt coated and wrapped steel pipe.

B. Pipe Class or Working Pressure shall be 150 psi unless otherwise specified. This specification includes all classes and specific tables for Class 100, 150, and 200 psi.

C. Nominal Pipe Diameter shall mean the approximate inside diameter of the cement mortar lining.

D. Fabricated Steel Plate Specials, defined as bends, wyes, reducers, outlets, and other pipe structures.

1.02 QUALITY ASSURANCE
Includes the requirements of this specification and the requirements of the latest revision of the following standards as applicable. Unless specifically stated otherwise, the most stringent requirement will govern when there is a conflict.


B. AWWA C-203. AWWA C-203 coal-tar protective coatings for hot applied enamel and tape.
C. AWWA C-205. AWWA C-205 cement mortar lining and coating. Section 5.5.4 wire mesh: When wire mesh is used as the reinforcement for the coating, it shall have a minimum of 1/2" coating over the wire mesh.

D. AWWA C-208. Standard dimensions for steel water pipe fittings.


   1. Type II Cement.
   2. Type V Cement.


1.03 SUBMITTALS

A. Pipe Layout Drawings. Pipe (36 inches and larger) shall be fabricated to adhere to the contract construction drawings. The Contractor shall submit pipe layout drawings for approval by the Engineer when the pipe layout varies from the alignment or grade shown on the contract drawings. These drawings shall be the same scale as the contract drawings. The District will allow the manufacturer to utilize a set of reproducible contract drawings to reflect the proposed deviations from the planned grades. Departures from line and grade within the following parameters will be permitted in the manufacture of the pipe to allow the use of joint pulls to effect changes of alignment:

1. Horizontal alignment shall be within 4 inches of the alignment shown on the contract drawings.

2. In vertical alignment, depth may be reduced 1 inch or increased 4 inches if the following minimum vertical clearances between outside diameters of other facilities are maintained and no additional highpoints are created:
   a) 1 foot vertical clearance between sewer and water pipelines.
b) 0.5 foot vertical clearance between all other facilities except when specifically shown otherwise on the contract drawings.

3. Horizontal location of the vertical P.I. may deviate by 0.5 feet.

(Pipe smaller than 36 inch may be straight run pipe with horizontal and vertical bends fabricated to conform to construction drawings and welded to straight run pipe with butt straps per Standard Drawing B-304 or other approved full welded joint connections.)

Proposed departures in excess of these limits must be approved by the Engineer prior to initiation of layout drawings.

Computer printouts will be accepted in lieu of layout drawings except for such proposed departures.

B. Fabricated Steel Plate Specials. Fabricated steel plate specials submittals shall be approved prior to fabrication. The dimensions shall conform to AWWA C-208 except as modified herein or as otherwise shown on the plans.

1. Pipe Outlets. The measurement from the outside of pipe to the face of flange shall be 12" unless otherwise shown. Outlets shall be designed per AWWA Manual M-11, and design of stiffner plates shall follow the nomograph method.

Pipe outlets shall also be provided for chlorination corp stops, air valve assemblies, services, and other appurtenances required by the contract drawings. Brass plugs shall be provided for installation upon later removal of the chlorination corp stops.

2. Bends

   a) The radius of bends shall be a minimum of 2½ times the pipe diameter unless specified otherwise.

   b) Bends may be welded to adjacent pipe sections.

   c) Bends shall conform to the following table:

<table>
<thead>
<tr>
<th>Piece</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-piece</td>
<td>0° - 30°</td>
</tr>
<tr>
<td>3-piece</td>
<td>30° - 45°</td>
</tr>
<tr>
<td>4-piece</td>
<td>45° - 67½°</td>
</tr>
<tr>
<td>5-piece</td>
<td>67½° - 90°</td>
</tr>
</tbody>
</table>
C. **Rubber Gaskets.** Test results showing the properties of the material used in the rubber gaskets shall be submitted by the Contractor if requested by the Engineer.

D. **Pipe Design.** Pre-tensioned concrete cylinder pipe reinforcing steel shall be computed as follows:

\[ A_s = \frac{6 P_w D_y}{f_s} \]

Where:

- \( A_s \) = Total cross-sectional area of circumferential steel (cylinder plus bar reinforcement) --- sq. in./ft. of pipe
- \( P_w \) = Pressure Rating (Class) --- psi
- \( D_y \) = Inside diameter of steel cylinder – inches
- \( f_s \) = Average circumferential stress in psi in the steel cylinder and bar reinforcement when the section is subjected to working pressure

and

- \( f_s \) = is not to exceed 16500 psi nor 50% of the specified minimum yield strength of the steel used in the cylinder. Bar reinforcement shall not be greater than 60% of the total area of circumferential reinforcement.

1.04 **DELIVERY**

Pipe and material shall be furnished, delivered and strung along the trench site.

A. **Internal bracing** adequate for handling and transportation shall be installed as soon as practical after the application of cement mortar lining. All bracing shall remain in the pipe until installation and backfilling are completed.

B. **Gasket material** shall be furnished with the pipe for storage in a cool, well ventilated place and protected from direct sunlight.

1.05 **JOB CONDITIONS**

Pipe and materials shall not be fabricated, stored, or installed in climatic conditions that will adversely affect the quality of the finished pipeline project.
1.06 ALTERNATIVES
Pipe for projects that are federally funded, in part or whole, shall also meet or exceed federal requirements:

A. **Steel pipe** shall conform to federal specification SS-P-385A for cement mortar lined and reinforced cement mortar coated pipe.

B. **Pre-tensioned concrete cylinder pipe** shall conform to federal specification SS-P-381B.

PART 2 - PRODUCTS

2.01 MATERIALS
For all steel manufactures outside the United States, the Contractor shall submit to the District, for its approval, a certified letter stating that the steel meets or exceeds the following: all of the requirements of AWWA C-200, the applicable ASTM Standards, and this Specification, and provide certified physical and chemical test results. The manufacturer of the steel cylinder shall be responsible for all requirements of these specifications. Manufacturers must be per EMWD's "approved materials list" and are: Ameron, Continental Pipe Manufacturing Co., Mid America Pipe, Northwest Pipe Company and Rosco Moss.

A. **Cement Mortar Lined Steel Pipe Cylinder**

1. Steel thickness shall be at least 12 ga. (0.1046").

2. Steel thickness shall be determined from the pressures imposed (Class) and the design stress of the steel. Design stress is defined as one-half ( minimum yield stress of the steel.

3. Steel pipe shall conform to the following table which includes minimum diameters and minimum thicknesses for various classes and nominal diameters. Note: Plate thickness is based on steel with a yield stress of 33,000 psi and a design stress equal to 50% of the yield stress (16,500 psi).

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Minimum Cylinder Diameter</th>
<th>Class 200 Min. Cylinder Plate Thickness</th>
<th>Class 150 Min. Cylinder Plate Thickness</th>
<th>Class 100 Min. Cylinder Plate Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot;</td>
<td>4-1/2&quot;O.D.</td>
<td>0.1046&quot;</td>
<td>0.1046&quot;</td>
<td>0.1046&quot;</td>
</tr>
<tr>
<td>6&quot;</td>
<td>6-5/8&quot;O.D.</td>
<td>0.1046&quot;</td>
<td>0.1046&quot;</td>
<td>0.1046&quot;</td>
</tr>
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<tr>
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<td>0.1046&quot;</td>
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<tr>
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<td>0.1280&quot;</td>
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Steel Cylinder Water Pipe
Section 15061 – 6

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Minimum Cylinder Diameter</th>
<th>Class 200 Min. Cylinder Plate Thickness</th>
<th>Class 150 Min. Cylinder Plate Thickness</th>
<th>Class 100 Min. Cylinder Plate Thickness</th>
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<tr>
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<tr>
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<td>0.2517&quot;</td>
<td>0.1683&quot;</td>
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</tbody>
</table>

4. Cylinder shall conform to AWWA C-200.

5. Cement mortar lining shall conform to AWWA C-205.

6. Separate joint rings, if used, shall conform to Section 2.6, AWWA C-303.

B. Pre-tensioned Concrete Cylinder Pipe

1. Shall conform to the following table:

**PRE-TENSIONED CONCRETE CYLINDER PIPE**

**WORKING PRESSURE**

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Cylinder Diameter</th>
<th>Plate Thickness</th>
<th>Total Area (sq.&quot;/ft)</th>
<th>Plate Thickness</th>
<th>Total Area (sq.&quot;/ft)</th>
<th>Plate Thickness</th>
<th>Total Area (sq.&quot;/ft)</th>
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<tr>
<td>12&quot;</td>
<td>12-3/4&quot;O.D.</td>
<td>12ga.</td>
<td>1.485</td>
<td>12ga.</td>
<td>1.485</td>
<td>12ga.</td>
<td>1.485</td>
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<td>12ga.</td>
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<td>1.485</td>
<td>12ga.</td>
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<tr>
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<td>1.485</td>
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</tr>
<tr>
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<td>1.485</td>
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<td>1.485</td>
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<tr>
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<tr>
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<td>1.525</td>
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<tr>
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<td>1.737</td>
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<td>1.555</td>
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<tr>
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<td>1.902</td>
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<td>1.585</td>
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<tr>
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<td>2.755</td>
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<td>2.230</td>
<td>12ga.</td>
<td>1.645</td>
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<tr>
<td>Nominal Pipe Diameter</td>
<td>Cylinder Diameter</td>
<td>Plate Thickness</td>
<td>Total Area (sq.&quot;/ft)</td>
<td>Plate Thickness</td>
<td>Total Area (sq.&quot;/ft)</td>
<td>Plate Thickness</td>
<td>Total Area (sq.&quot;/ft)</td>
</tr>
<tr>
<td>-----------------------</td>
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<td>----------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>42&quot;</td>
<td>43-7/8&quot;O.D.</td>
<td>11ga.</td>
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<td>2.393</td>
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<td>2.720</td>
<td>11ga.</td>
<td>1.915</td>
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<tr>
<td>54&quot;</td>
<td>55-7/8&quot;O.D.</td>
<td>9ga.</td>
<td>4.063</td>
<td>11ga.</td>
<td>3.048</td>
<td>11ga.</td>
<td>2.032</td>
</tr>
</tbody>
</table>

12 ga. = .1046 = 1.255 square inch/ft.
11 ga. = .1196 = 1.435 square inch/ft.
10 ga. = .1345 = 1.614 square inch/ft.
9 ga. = .1495 = 1.794 square inch/ft.

2. Rod reinforcing shall conform to ASTM A615 GR40, and the minimum diameter shall be 7/32".

3. Shall conform to AWWA C-303.

C. Coatings

1. Pre-tensioned concrete cylinder pipe shall be coated per AWWA C-303 except the cement shall be Type II or Type V.

2. Cement mortar lined steel pipe shall be cement mortar coated unless specified otherwise.

a) Cement Mortar Coating

(i) Shall be a minimum of 3/4" thick.

(ii) Shall either be Type II or Type V cement, unless specifically stated on the plans or in the Special Conditions.

(iii) Shall be one type of cement; i.e., Type II & V shall not be mixed together.

(iv) Shall meet or exceed AWWA C-205 requirements.

(v) Shall be of adequate thickness to provide required rigidity and corrosion protection.

b) Coal-Tar Enamel Coated and Wrapped Coating shall conform to AWWA C-203

(i) Type B primer shall be used.

(ii) Coal-tar enamel may be Type I or Type II.
Wrapping shall be a single layer of glass mat or 15-pound coal tar saturated asbestos felt.

The coating shall be whitewash.

c) Asphalt Coated and Wrap Coating shall use

(i) Asphalt primer.
(ii) Asphalt (hot applied).
(iii) Mica surfaced 15-pound pipeline felt.

d) Field painting shall be used on above-ground installation as shown on the drawings.

e) Bare metal shall be coated with a suitable primer for its intended use.

D. Steel Plate Specials

1. Shall be constructed of steel plate, thickness computed from the greater of the following criteria, unless a still greater requirement is shown on the drawings or stated in the special conditions:

a) Thickness not less than 3/16"; or

b) Thickness as determined from the formula

\[
T \geq \frac{D \times P}{2 \times 12,500}
\]

Where:

- \( T \) = wall thickness in inches
- \( D \) = inside diameter of steel cylinder in inches
- \( P \) = design pressure (class) in pounds per square inch

2. Schedule 30 or heavier steel pipe in standard diameters may be used in lieu of above paragraph "2.01, D1" for outlets that are 12" and smaller diameter (12.75", 10.75", 8.625", 6.625" and 4.5" outside diameters).

3. Steel welding fittings conforming to the requirements of ASTM Designation A-234 may be used when available in suitable sizes.

4. Cement mortar lining meeting AWWA C-205 except handwork reinforcement shall be 2"x 4" No. 12 welded wire fabric.
5. Coating meeting the requirements of straight pipe.


7. Reinforced steel collar pads designed for the specified pressure where needed.

8. Materials meeting or exceeding AWWA C-200 requirements.

E. Rubber Ring Gaskets

1. Shore durometer hardness range shall be in the range of 50-55 in accordance with ASTM D-2240.

2. Compound shall conform to the requirements of Section 2.8 AWWA C-303.

2.02 MIXES
All mixes shall conform to the applicable reference sections.

2.03 FABRICATION OF PIPE

A. Steel cylinder pipe shall be fabricated in accordance with:

1. AWWA C-200 for cement mortar lined steel pipe.

2. AWWA C-303 for pre-tensioned steel cylinder steel pipe.

B. Cement mortar lining process shall be followed with sealing each pipe end with a waterproof cover prior to carefully moving the pipe section. The pipe sections shall be cured under sprinklers or by other processes approved by the Engineer.

C. Coatings shall be applied after the exterior of the pipe is thoroughly cleaned and free from all loose mill scale and rust.

1. Cement mortar coating shall be applied pneumatically or by impaction resulting in a dense uniform coating that adheres tightly to the pipe.

2. Coal-tar enamel and wrapped coating shall be applied in accordance with AWWA C-203.

3. Asphalt coating and wrapping.

   a) Shall be applied after pipe is fabricated and hydrostatically tested.
Steel Cylinder Water Pipe  
Section 15061 – 10

b) Asphalt primer.
   
   (i) Shall be applied to clean-dry surfaces to produce a suitable bond between the metal and subsequent coating of asphalt.

   (ii) Shall be uniform and free from bare spots.

   (iii) Shall be protected from rain and fog during and between applications.

c) Hot asphalt shall be applied after the primer has completely hardened and with, or immediately preceding, the wrapping material in sufficient quantity to form a bead on the exposed edge of wrap.

d) Wrapping material shall be spirally wrapped under tension to ensure complete coverage, 3/4" lap at edge, no wrinkles and buckles, and complete cementing to the pipe with hot asphalt.

e) Coating and wrapping shall be omitted at each end for a sufficient distance to permit the making of field joints. All exposed bare metal shall be coated with a suitable primer.

D. Joints

1. All pipes shall have rubber gasket joints unless otherwise shown.

   a) The steel area in the bell shall not be less than the area in an equivalent length of pipe barrel.

   b) Rubber gasket ends formed integrally with the steel cylinder shall be formed either by sizing with a machined swage or die, or by rolling per AWWA C-200.

   c) Separate rubber gasket joint rings shall be formed per requirements of Section 3.3 of AWWA C-303.

2. Ends that are not rubber gasket, including but not limited to weld bells, plain ends, grooved ends, and butt straps shall conform to AWWA C-200 where applicable, and to the construction drawings.

3. Flanges shall conform to Eastern Municipal Water District standard drawing B-288.

E. Steel Plate Specials shall conform to approved shop drawings and shall be fabricated in a shop approved for that purpose by the Engineer.
1. Each special shall have a mark on the top and bottom corresponding to the true vertical axis.

2. Outlets, including wyes, shall be built into the wall of the pipe.

3. Fabricated steel fittings of suitable design shall be welded to the cylinder before the exterior coating is placed around the fittings.

4. Cement mortar lining shall meet the requirements of straight pipe with the provisions that handwork lining reinforcement shall be positioned approximately in the center of the lining. The wires spaced 2" on center shall extend circumferentially around the pipe. The fabric shall be securely fastened to the pipe. Splices shall be lapped 4" and the free ends tied or looped to ensure continuity.

PART 3 - EXECUTION

3.01 INSPECTION

A. Notification of Manufacture. Unless specifically waived, EMWD Inspection Department shall be notified at least 48 hours prior to commencement of the manufacture of pipe.

B. Hydrostatic Testing. Steel cylinders shall be hydrostatically tested to a stress equal to 75% of the minimum yield point of the steel. Certification of all cylinders is required by the District.

C. Specials. Specials shall be bulkheaded and tested prior to lining and coating of weld seams at one-and-one-half (1½ ) times the design pressure (class). Dye penetrant process may be used on all untested welds in lieu of hydrostatic testing if the straight pipe used in fabricating the special has passed a hydrostatic test of 75% of the yield point. All defective welds including pinholes and porous welds shall be chipped out, rewelded, and retested.

D. Soap and Compressed Air Test

1. All double-welded lap joints, butt-strap joints, and other joints susceptible to this test shall be tested by the soap and compressed air method as hereinafter described. After completion of the shop hydrostatic test of the pipe sections the soap and compressed air test also may be used instead of hydrostatic testing of welded joints in the steel manhole outlets, which are attached to steel-plate sections.
2. As soon as practicable after the welding of each joint to be tested by the soap and compressed air test has been completed, the Contractor shall subject each joint to a soap test by forcing compressed air, at approximately 40 pounds pressure per square inch, into each said joint and, while the joint is under pressure, every portion of every welded seam forming a part of the joint shall be swabbed with a heavy soap solution or an approved, commercial, bubble producing leak test fluid and shall be carefully examined for leakage. The Contractor shall repair any defects disclosed by the test by chipping out and rewelding the chipped section, after which the same test shall again be applied. The Contractor shall provide all apparatus and materials for making the tests, shall drill and tap the necessary holes and shall plug weld the holes after testing.

E. Rubber Gaskets. Rubber gaskets shall be subject to inspection and/or testing by the Engineer. All unsatisfactory gaskets shall be immediately replaced at no expense to the District.

F. Manways. All 30" diameter and larger pipe shall have 24" diameter or larger access manways within 750 feet of any interior point of the pipeline.

1. Manways shall consist of 24" diameter outlets with 24" blind flanges.

2. Manways shall have a maximum spacing of 1500 feet on center. At valve installations, manways shall be located on both sides of each valve a maximum of 35 feet.

3. Outlets or bumped heads that provide an equal or larger opening than a 24" manway may be used for pipe access.

4. Manway locations shall be selected to minimize impact to traffic, and shall be approved by EMWD prior to pipe fabrication.

3.02 INSTALLATION

A. Preparation. Internal bracing, in addition to the bracing used for handling and transportation of the pipe, shall be installed when required to ensure maximum permissible deflections are not exceeded during laying, backfill, and compaction.

B. Pipe Zone Density. Relative compaction in pipe zone III as shown on standard drawing B-286B shall be in accord with the manufacturer's recommendation. All pipe bid for this project shall meet EMWD's minimum standards as set forth in Section 15061 herein. The Contractor, in conjunction with the pipe manufacturer, will indicate in the space provided and attached hereto as part of the bid forms, the pipe zone compaction to be constructed, the mortar thickness - both lining and coating - and the trench slope construction.
C. **Diapers** shall be impervious if available.

   1. Width of diapers, where used, shall be sufficient to allow cupping of the diaper for increased thickness of the joint mortar. Recommended minimum diaper widths:
      
a) 20" dia. pipe and larger: 12"

b) 12" - 18" dia. pipe: 10"

c) 10" dia. pipe and smaller: 9"

   2. Mortar placement shall be from one side of the diaper, to allow the mortar to flow around the bottom and up the opposite side of the pipe, to preclude the possibility of any voids inside the diaper.

D. **Curing** operations shall begin immediately after completion of joint mortaring.

   1. Immediate backfill should follow the completion of the joint mortaring operation where possible. Care must be taken to immediately wet down and consolidate the backfill, to avoid draining the moisture from the mortar through porous diapers into dry backfill soil, or disturbing the mortar set by subsequent compaction of the backfill.

   2. Completed-joint mortar to be exposed to the sunlight where backfill will not take place until after the mortar has hardened must be kept continually moist during the curing period to prevent cracking of the curing mortar.

**END OF SECTION 15061**
Steel Cylinder Water Pipe
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SPECIFICATIONS - DETAILED PROVISIONS
Section 15064 - Plastic (PVC) Pressure Water Pipe & Fittings

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  1.04 MEASUREMENT AND PAYMENT ............................................................................................... 1

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PART 1 - GENERAL

1.01 REQUIREMENT
It is required that the Contractor shall furnish, deliver, unload and string along the trench site, all pipe and material as hereinafter described in the specifications. All fabrication, workmanship, material and testing of pipe shall conform to the latest revision of the specifications.

1.02 DELIVERY

A. Transport, deliver, unload, store and handle all materials in a manner to prevent damage to the materials or the work.

B. All damaged, broken or otherwise defective materials will be rejected.

C. Store all circular rubber gaskets and special lubricants in packaged materials with the manufacturer’s name, brand and all other applicable data plainly marked thereon.

1.03 QUALITY ASSURANCE
Unless otherwise specified, all work specified herein and as shown on the drawings shall conform to the applicable requirements of the latest revision of the following standards. Unless specifically stated otherwise, the most stringent requirement will govern when there is a conflict.

A. AWWA C-900. American Water Works Association (AWWA) C-900 standard for polyvinyl chloride (PVC) pressure pipe 4 inches through 60 inches for water.

B. Any pipe showing discoloration, chaulking, checking or other visible damage due to ultraviolet light exposure shall not be accepted by the District.

1.04 MEASUREMENT AND PAYMENT
Payment for pipe shall be made on a unit price basis per lineal foot of pipe.
PART 2 - PRODUCTS AND MATERIALS

2.01 TYPE OF PVC PIPE
PVC pipe and fabricated fittings shall be made from virgin PVC resin that has been compounded to provide physical and chemical properties that equal or exceed cell class 12454 as defined in ASTM D1784 providing a hydrostatic design basis (HDB) of 4000 p.s.i. in accordance to AWWA C-900. Pipe shall have cast iron outside diameters.

All rubber rings shall be furnished by the pipe manufacturer. These rubber rings (elastomeric gaskets) shall be manufactured to conform with the requirements of ASTM F-477.

2.02 PIPE CLASS OR WORKING PRESSURE
AWWA C-900 PVC pipe shall be Pressure Class 235 and shall have a Dimension Ratio of 18.0 (DR-18).

2.03 TYPE OF FITTING
Fittings for PVC pipe shall be flanged or bolted mechanical joint or push-on joint ductile or gray iron fittings and shall conform to ANSI/AWWA C110/A21.10 or C153/A21.53, and ANSI/AWWA C111/A21.11. All fittings shall be cement mortar lined and tar (seal) coated in accordance with ANSI/AWWA CI04/A21.4.

2.04 RESTRAINED SYSTEM
Restrained Joints shall be provided by a clamping ring and an additional ring designed to seat on the bell end of the pipe. The rings shall be connected with T-Head bolts or rods. Restraining devices shall provide full (360 degree) support around the circumference of the pipe. No point loading shall be permitted. Restraint of mechanical joint fittings shall be provided by a clamping ring installed on the PVC pipe and connected to the mechanical joint fitting with T-Head bolts or rods. Restraining devices shall meet or exceed the requirements of ASTM F-1674 or UNI-Bell B-13 "Recommended Standard Performance Specification for Joint Restrainers for Use with PVC Pipe." Restraining devices shall be UNI-Flange Series 1300 or 1350 or approved equal.

All buried steel parts shall be sand blasted in accordance with the coating manufacturer's technical data sheet for "submerged" service and coated with a two coat epoxy. Epoxy shall be Tnemac Series 66 or equal. All bolts and tie rod materials shall be either high strength cast iron containing a minimum of 0.5% copper or high-strength, low alloy steel, as specified in AWWA C-111 for buried mechanical joints.

2.05 SERVICE CONNECTION OUTLETS
All service connections to PVC pressure pipe water main shall be constructed with bronze service saddles with CS threads for receiving a bronze corporation stop in accordance with standard drawings. Service saddle shall be Jones, Mueller, or approved equal.
2.06 POLYETHYLENE ENCASEMENT
All ductile or gray iron fittings shall be encased with V-Bio enhanced polyethylene at the time of installation. Polyethylene encasement and installation shall be in accordance with ANSI/AWWA C105.

PART 3 - EXECUTION

3.01 FACTORY TESTING
All pipe shall be tested in the United States in accordance with AWWA C900 and certification of the testing shall be furnished to the engineer upon his request prior to delivery. The engineer may be present during physical testing of pipe.

3.02 INSTALLATION
PVC pipe shall be installed in accordance with Sections 02718 and 02201 of Eastern Municipal Water District Specifications.

END OF SECTION 15064
SPECIFICATIONS - DETAILED PROVISIONS
Section 15077 - Grooved Couplings

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PART 1 - GENERAL

1.01 DESCRIPTION
Where specified, mechanical grooved couplings and fittings shall be cast of malleable iron conforming to ASTM A-47 or ductile-iron ASTM A-536. The coupling shall be of the grooved, mechanical type which engages grooved pipe ends. The coupling shall be cast in two or more parts per manufacturer's standard. Coupling gasket shall be of molded synthetic rubber EPDM Grade "E" conforming to ASTM D-2000 designation 2CA615A15B44F17Z. Bolts and nuts shall be heat treated carbon steel conforming to ASTM A-183, minimum tensile 110,000 psi and oval neck track head type. Fittings shall be of grooved-end design to accept grooved mechanical couplings with or without field preparation as applicable. Couplings for grooved steel pipe shall be "Victaulic" Style 77 or approved equal. Couplings for grooved ductile iron or cast iron pipe shall be "Victaulic" Style 31 or approved equal.

END OF SECTION 15077
[PAGE LEFT INTENTIONALLY BLANK]
PART 1 - GENERAL

1.01 REQUIREMENT
Gaskets for steel and cast iron flanges shall be of dimensions conforming to the requirements of Standard Drawing B-288, and shall be standard full face for pipe 27” diameter and larger.

Gaskets shall be 1/16", non-asbestos model # Garlock 3000 or Tripac 5000.

1.02 FLANGE INSULATING GASKET KITS
A. Pipe flange insulating kit materials shall be of the type designated by the manufacturer as suitable for appropriate service at the operating temperatures and pressures specified on the Plans.

B. Flange insulating kits shall consist of a one piece full-face, insulating gasket, an insulating sleeve for each bolt, two insulating washers for each bolt, and a steel washer between each insulating washer and nut.

1. Insulating gasket shall be a full faced NEMA Grade G-10 Glass Epoxy Laminated Retainer with a precision tapered groove to accommodate the compression of a BUNA-N or VITON sealing element. Minimum total thickness shall not be less than 1/8-inch. Dielectric strength shall be not less than 550 volts per mil, and compressive strength of not less than 50,000 psi. Use PSI Linebacker or equal.

a. Optional Materials:
   1. Neoprene faced phenolic gasket

2. Insulating sleeves shall be full length, one piece, insulating flange bolt sleeves for the appropriate bolt size. Insulating sleeves shall be NEMA G-10 Glass Epoxy Laminated tubing (Pyrox). Dielectric strength shall be not less than 400 volts per mil.

a. Optional Materials:
   1. Phenolic tubing
   2. Nomex tubing
   3. Mylar tubing
   4. Polyethylene tubing

3. Insulating washers shall be NEMA Grade G-10 Glass Epoxy Laminated Washers with a minimum thickness of 1/8-inch. Dielectric strength shall not be less than 550 volts per mil, and compressive strength of not less than 50,000 psi.
Gaskets
Section 15081 – 2

a. Optional Materials:
   1. Phenolic Washers
   2. Nomex Washers

4. Provide cadmium plated steel flange bolt washers for placement over the insulating washers with a minimum thickness of 1/8 inch.

END OF SECTION 15081
PART 1 - GENERAL

1.01 REQUIREMENT
Bolts and nuts for flanged fittings shall be bare steel conforming to SAE J429 Grade 5 or ASTM A449 medium carbon steel quenched and tempered meeting the following requirements, and shall have hex heads and lite-pattern hex nuts.

\[
\begin{align*}
\frac{1}{4}” \text{ Through 1” diameter} & \\
85,000 \text{ p.s.i. proof strength} & \\
92,000 \text{ p.s.i. yield strength} & \\
120,000 \text{ p.s.i. tensile strength} & \\

\text{Over 1” to 1½” diameter} & \\
74,000 \text{ p.s.i. proof strength} & \\
81,000 \text{ p.s.i. yield strength} & \\
105,000 \text{ p.s.i. tensile strength} &
\end{align*}
\]

1.02 USE OF ZINC CAPS FOR BURIED PIPE
Each bolted fitting including couplings, flange adapters, restrained joints, etc. that have manufactured bolts and nuts shall have a minimum of 2 zinc caps anodes as specified below.

Bolt sizes and number of zinc caps:

through 1” diameter - 2 zinc caps
over 1” diameter - 4 zinc caps

Weight of zinc caps:

Zinc caps to be 6 oz. weight.

Material reference:

Zinc caps shall be per ASTM B418-80 and Mil-A-18001J, and be manufactured by Mars, Reliance, or equal.

END OF SECTION 15089
# SPECIFICATIONS - DETAILED PROVISIONS
## Section 15102 - Resilient-Seated Gate Valves

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PART 1 - GENERAL

1.01 DESCRIPTION
The Contractor shall furnish, deliver, and unload within the time specified in the Special Conditions, the resilient-seated gate valves as hereinafter described.

1.02 QUALITY ASSURANCE
Quality Assurance includes the requirements of this specification and the requirements of the latest revision of the following standards, as applicable. Unless specifically stated otherwise, the most stringent requirement will govern when there is a conflict.

A. AWWA C-509. American Water Works Association Standard for Resilient Seated Gate Valves, 3” through 30” NPS, for Water and Sewage Systems

B. AWWA C-515. American Water Works Association Standard for Reduced–Wall, Resilient Seated Gate Valves, 3”-16” & 3”-36” NRS.


1.03 SUBMITTALS
The name of the manufacturer of the valves to be furnished by the bidder shall be stated on the bidding sheets. Proposed valves other than those listed on the EMWD approved Material List must be submitted for evaluation well in advance of the bid opening, for acceptance prior to the award of the contract. Generally, the specified 35-day period following issuance of the Notice-of-Acceptance-of-Proposal is not sufficient for approval of alternate valves.

1.04 PRODUCT DELIVERY

A. Storage. Valves shall be stored in the closed position to protect seating surfaces.

B. Handling. Valves shall be carefully lowered from the truck to the ground. Do not hook hoists or fasten chains around stem, gearing, motors, cylinders, or handwheels.

1.05 JOB CONDITIONS
Valves shall not be fabricated, stored, coated, or installed in climatic conditions that will adversely affect the quality of the finished project.
1.06 ALTERNATIVES
Valve ends shall be as specified on the bidding sheet, plans or specifications as applicable; these may be flanged both ends, hub-end both ends, or one flanged end and one hub-end, conforming to the following specifications:

A. **Flanged End.** Flanged ends shall be designed for the water pressure as specified in AWWA C-509 and drilled to the American Standard for 125# Cast Iron Flanges, and flange face shall not be raised. Flange face shall have standard machine finish.

B. **Hub-End.** Hub-ends shall be designed for the water pressure as specified in AWWA C-509 and shall be "Ring-tite", "Fluid-tite" or approved equal.

1.07 GUARANTEE
Contractor shall guarantee all materials and workmanship of items furnished under these specifications shall be free from defects for a period of one (1) year after final completion and acceptance of the entire contract work. The Contractor shall, at his own expense, repair or replace all defective materials or workmanship supplied by him that are found to be deficient with respect to any provisions of this specification.

PART 2 - PRODUCT

2.01 MATERIALS
Resilient Seated Gate Valves shall include the following materials:

A. **Non-Rising Stems.** Clockwise to close, counterclockwise to open. Valve stems shall be of bronze, having a minimum tensile strength of 55,000 psi and a yield point of not less than 40,000 psi, with an elongation of not less than 10% in 2". Heat treatment will be permitted to develop these requirements. All bronze shall contain not more than 7% zinc nor more than 2% aluminum.

B. **2" Square Nut** with arrow cast in metal to indicate opening direction, except where specified otherwise.

C. **Resilient Seats** may be bonded or mechanically attached to either the gate or valve body.

2.02 COATINGS
A. All valves shall have internal and external ferrous parts epoxy coated. Wetted surfaces shall have an 8 mil minimum (dry film) thickness, unless otherwise specified. The epoxy shall be approved for potable water, and shall conform to AWWA C-550.
B. All coated surfaces shall be visually and electrically examined for defects. The coating shall be holiday free as determined by a low voltage wet sponge test per AWWA C-550.

2.03 FABRICATION AND MANUFACTURE

A. Interchangeability. All like parts of all valves of the same model number and size shall be interchangeable.

B. Waterway. With the valve open, there shall be a smooth and unobstructed waterway at least equal to the nominal valve diameter. There shall be no sediment pockets in the valve.

C. Valve Actuator. Resilient Seated Gate Valves 16-inches through 36 inches shall have a gear reduction actuator that meets the following maximum values for torque and number of turns:

<table>
<thead>
<tr>
<th>Valve Size</th>
<th>Maximum Input Torque (ft. lbs.)</th>
<th>Maximum Number of Turns to Open/Close</th>
</tr>
</thead>
<tbody>
<tr>
<td>16”</td>
<td>65</td>
<td>200</td>
</tr>
<tr>
<td>18”</td>
<td>80</td>
<td>225</td>
</tr>
<tr>
<td>20”</td>
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<td>250</td>
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<tr>
<td>24”</td>
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<td>310</td>
</tr>
<tr>
<td>30”</td>
<td>350</td>
<td>380</td>
</tr>
<tr>
<td>36”</td>
<td>385</td>
<td>450</td>
</tr>
</tbody>
</table>

D. Cast Marking. Valves shall have the manufacturer's name, the size of the valve, and the working pressure cast on the side of the valves.

E. Stem Sealing. Stems shall be sealed by the use of multiple stem seal o-rings.

PART 3 - EXECUTION

3.01 INSPECTION

A. Hydrostatic Tests. All valves shall have hydrostatic shell test of 400 psi and a bubble tight shut-off test of 200 psi.

B. Coating Tests. All coated surfaces shall be visually and electrically examined for defects. The coatings shall be holiday free with a low voltage wet sponge test per AWWA C-550.

C. Operation Test. Each valve shall be operated through one complete cycle in the position for which it is designed, to ensure proper functioning of all parts.
D. Additional Testing (RSGVs 16-inch and Larger). Resilient Seated Gate Valves 16-inch and larger shall be hydrostatically tested and performance tested per AWWA C509 and C515. This test shall be conducted within 100 miles of the District office and shall be performed in the presence of a District Inspector. No valve shall be installed until this testing has been completed and approved by the District. Each valve shall be tested as detailed in AWWA and District Standard Specifications and as specified below:

1. Visually inspect each valve for obvious damage, substandard construction and compliance with specifications.
2. Each valve shall be operated through one complete cycle in the position for which it is designed, to ensure proper functioning of all parts.
3. Each valve shall be hydrostatically tested at its rated pressure. The testing medium shall be water (no air shall be used as the test medium under any circumstance). Both sides of the valve are to be tested.
4. The test duration on each side of the valve shall be 5 minutes. A passing test is one where there is no visible leakage and no decrease in the initial test pressure.
5. A valve that fails the hydrostatic test shall be either repaired or replaced. Repaired/replaced valves shall be retested using the same procedure.
6. Valves shall only be repaired by personnel authorized by the valve manufacturer. Unless specifically authorized by the valve manufacturer, supplier or contractor shall not be permitted to perform repairs.

3.02 PREPARATION
Valves shall be complete when shipped. They shall be drained and closed before shipment.
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PART 1 - GENERAL

1.01 REQUIREMENT
Butterfly valves for buried water system service. Under this specification the Contractor shall be required to furnish, deliver, and unload within the time specified in the Special Conditions, the butterfly valves as specified on the bidding sheets and hereinafter described in these specifications.

1.02 VALVE MANUFACTURER
The name of the manufacturer of the valves to be furnished by the bidder shall be stated on the bidding sheets. Inasmuch as valves require an in-service review over an extended period of time for evaluation by the District for acceptance, it is necessary that proposed valves other than those specified must be submitted for evaluation well in advance of the bid opening, for acceptance prior to the award of the contract. Generally, the specified 35-day period following issuance of the Acceptance-of-Proposal will not result in approval of alternate valves.

1.03 GUARANTEE
The Contractor shall guarantee all materials and workmanship of items furnished under these specifications to be free from defects for a period of one (1) year after final completion and acceptance of the entire contract work. The Contractor shall, at his own expense, repair or replace all defective materials or workmanship supplied by him found to be deficient with respect to any provisions of this specification.

PART 2 - PRODUCT

2.01 VALVES
Butterfly valves shall conform to the latest revision of AWWA Standard C-504 for rubber-seated butterfly valves, subject to the following requirements: Valves shall be of Class 150B, shall have 125-lb. American Standard flanges and, unless otherwise shown, shall be short-bodied. Shaft seals shall be rubber "O"-ring, and journal packing shall be rubber or split-V type packing.

All valves shall be new and of current manufacture and shall be per EMWD Acceptance list.

2.02 VALVE ENDS
Shall be as specified on the bidding sheet; either flanged both ends, hub-end both ends, or one flanged end and one hub-end, as required, conforming to the following specifications:
Butterfly Valves
Section 15103 – 2

A. **Flanged End.** Flanged ends shall be designed for the water pressure as specified in AWWA C-504 and drilled to the American Standard for 125# Cast Iron Flanges, and flange face shall not be raised. Flange face shall have standard machine finish.

B. **Hub-End.** Hub-ends shall be designed for the water pressure as specified in AWWA C-504 and shall be "Ring-tite" or approved equal.

2.03 OPERATORS
The valve shall be provided with a totally enclosed buried service operator designed for the full working pressure across the disc and conforming to the requirements of the above-referenced AWWA Standard. Valves shall be installed with the shaft in a horizontal position. The operators shall be side-mounted, equipped with a 2" operating nut and have a raised boss at the input shaft to accommodate a 5" pipe. The operating torque rating shall conform to Table I of the above referenced AWWA Standard for the pressure classification specified, and shall be designed in accordance with the requirements of AWWA C-504-80 Appendix. Operator input torque ratings shall fully comply with the above referenced AWWA Standard. Operation shall be clockwise to close, counterclockwise to open. The minimum number of turns to close valve shall have a minimum of two (2) turns per diameter inch and a maximum of five (5) turns per diameter inch of valve size.

Valve operator shall be oriented with respect to pipeline intersection in accordance with standard drawing No. B-577.

2.04 TESTS
Each valve body shall be tested by the manufacturer under a test pressure equal to twice its design water working pressure, and shall be shop-operated three (3) times in accordance with the requirements of AWWA Standard C-504.

C. **BUTTERFLY VALVES LARGER THAN 12-INCHES**
Butterfly Valve Testing. Butterfly valves with size greater than 12 inches shall be hydrostatically tested per AWWA C504 in both directions. This test shall be conducted within 50 miles of the District office and shall be performed in the presence of the District. No valve shall be installed until this testing has been completed and approved by the District.

Each valve shall be tested as detailed in the District Standard Specifications and as specified below:

1. Visually inspect each valve and its actuator for compliance with the submittal.
2. Visually inspect each valve for obvious damage or substandard construction.
3. The testing medium shall be water. Under no circumstances is air to be used as the test medium.
4. Each valve is to be tested at its rated pressure.

5. Both sides of each valve are to be tested.

6. The test duration on each side of the valve is 5 minutes. A passing test is one where there is no visible leakage and no decrease on the initial test pressure.

7. A valve which fails the pressure test shall be either repaired or replaced. Repaired valves shall be retested. Replacement valves shall be tested using this procedure.

8. Valves shall only be repaired by personnel authorized by the valve manufacturer to do the necessary repairs. Unless they have been authorized by the valve manufacturer, supplier or contractor shall not be permitted to perform repairs.

2.05 COATINGS

A. All valves shall have internal and external ferrous parts epoxy coated. Wetted surfaces shall have an 8 mil minimum (dry film) thickness, unless otherwise specified. The epoxy shall be approved for potable water, and shall conform to AWWA C-550.

B. All coated surfaces shall be visually and electrically examined for defects. The coating shall be holiday free as determined by a low voltage wet sponge test per AWWA C-550.

END OF SECTION 15103
# SPECIFICATIONS - DETAILED PROVISIONS
Section 15104 - Ball Valves

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PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes. (Metal body ball valves) (and) (plastic body ball valves)

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C 507 Ball Valves, Shaft or Trunnion Mounted, 6 Inch Through 48 Inch.

1.03 SUBMITTALS

A. Product Data

B. Metal Body Ball Valves: Affidavit of compliance with AWWA C 507.

PART 2 - PRODUCTS

2.01 METAL BODY BALL VALVES

A. Manufacturers: One of the following or equal.
   1. Lunkenheimer Company.
   2. MARPAC, Inc.

B. General
   1. Type: Non-lubricated, and capable of sealing in either flow direction.
   2. Conform to AWWA C 507.
   3. Stem Packing: Manually adjustable while valve is under pressure.
4. **Temperature Limits:** Suitable for operation between minus 20 and 350 degrees Fahrenheit.

**C. Materials**

1. **Valves in copper lines:** Bronze body with solder ends.

2. **Valves in steel and ductile iron piping:** Ductile iron or cast steel bodies, and ends as follows:
   a) Threaded for sizes 3 inch and smaller.
   b) Flanged for sizes larger than 3 inch.

3. **Ball:** Type 304 or Type 316 stainless steel.

4. **Seats:** TFE.

5. **Stem seals:** TFE or Viton.

2.02 **PLASTIC BODY BALL VALVES**

**A. Manufacturers:** One of the following or equal:

1. Asahi America

2. Chemtrol Division, NIBCO Inc.

**B. General:**

1. **Type:** Non-lubricated and capable of sealing in either flow direction.

2. **End connections:** True union.

3. **Operator handle:** Lever

**C. Materials:**

1. **Body:** Polyvinyl chloride (PVC).

2. **Ball:** Polyvinyl chloride (PVC).

3. **Seats:** TFE (Teflon).
PART 3 - EXECUTION

3.01 INSTALLATION

A. Follow manufacturer's published instructions.

END OF SECTION 15104
SPECIFICATIONS - DETAILED PROVISIONS
Section 15111 - Check Valves

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PART 1 - GENERAL

1.01 REQUIREMENT
Check Valves for water service. Under this specification the contractor shall furnish, deliver and unload, within the time specified in the Special Provisions, the check valves as specified on the Bidding Sheet and hereinafter described in these specifications.

PART 2 - PRODUCT

2.01 CHECK VALVES
Check valves shall be single disc, swing type, with spring and lever when so specified on the Bidding Sheet. At full open position, the area of the water way shall not be less than the area of the proposed connecting pipe area. Check valve bodies and all necessary parts shall be a size and type suitable for use with pressure as specified. Flanged ends shall be faced and drilled and back of flanges shall be spot-faced, in conformance with the "American 125 pound Cast Iron Flange Standard." Flange faces shall have standard machine finish.

Body seat rings shall be of bronze and of the removable type screwed into place. Disc shall seat tightly without slamming under specified working pressure. The disc shall have a bronze seat ring securely fastened to the disc.

Hinge-pins shall be stainless steel and bushing shall be either bronze or stainless steel. Hinge shall be solid bronze or stainless steel.

Check valves shall be subject to hydrostatic test of not less than 300 psi.

2.02 COATINGS
All check valves shall have all wetted ferrous parts epoxy coated. The epoxy shall be thermosetting, approved for potable water, and shall conform to AWWA C-550.

All coated surfaces shall be visually and electrically examined for defects. The coating shall be holiday free with a low voltage wet sponge test per AWWA C-550.

END OF SECTION 15111
PART 1 - GENERAL

1.01 REQUIREMENT
Under these specifications the Contractor shall be required to furnish, deliver and unload at the place stated, and within the time specified in the Special Requirements of these specifications, the valves as hereinafter described in these specifications.

PART 2 - PRODUCT

2.01 CONTROL VALVES
All control valves shall be flanged diaphragm type globe valves, with cast iron body, as manufactured by Cla-Val Company, or shall be of other makes approved by Eastern Municipal Water District. Type and size shall be as shown on the Bidding Sheets.

A. Coatings. All wetted ferrous parts, except stainless steel, shall be epoxy coated. The epoxy shall be thermosetting, approved for potable water, and conform to AWWA C-550.

B. Stems. Plastic sleeved stems (Delrin) shall be supplied except when specifically deleted.

C. Trim

1. Pressure Reducing Valves: Unless specifically stated otherwise, pressure reducing control valves shall have stainless steel trim.

2. Other Control Valves: All control valves other than pressure reducing valves shall have bronze trim.

END OF SECTION 15120
# SPECIFICATIONS - DETAILED PROVISIONS

## Section 15136 - Air Valves

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SECTION 15136
AIR VALVES

PART 1 - GENERAL

1.01 REQUIREMENT
Under these specifications the Contractor shall be required to furnish, deliver and unload at the place stated, and within the time specified in the Special Provisions, the air valves for water systems as specified on the Bidding Sheet and hereinafter described in these specifications. Air valves for sewerage systems are not included in this specification, but will be specifically called out on the construction drawings.

1.02 VALVE MANUFACTURER
The name of the manufacturer of the valves to be furnished by the bidder shall be stated on the Bidding Sheet. If valves different than listed herein are proposed, the bidder shall submit drawings of the proposed valves to the District prior to the time of opening bids. Bidder’s drawings need not be submitted if such drawings have previously been approved by the Engineer as to compliance with the specifications.

1.03 GUARANTEE
The Contractor shall guarantee all materials and workmanship of items furnished under these specifications shall be free from defects for a period of one (1) year after final completion and acceptance of the entire contract work. The Contractor shall, at his own expense, repair or replace all defective materials or workmanship supplied by him found to be deficient with respect to any provisions of this specification.

PART 2 - PRODUCT

2.01 MATERIALS
All valves shall have a body of high grade cast iron and have all internal parts of solid bronze or stainless steel. All valves shall be designed for a working pressure of not less than 150 p.s.i..

2.02 OPERATIONAL FEATURES

A. Air Valves. All valves shall be designed to automatically operate as specified herein:

1. Will positively open under atmospheric pressure to allow air to escape from the pipe through the valve.
2. Will positively close as water under low head fills body of the valve.

3. Will not blow shut under high velocity air discharge, to allow air to escape from pipe while pipe is being filled.

4. Will permit the escape of accumulated air under pressure, while pipeline is in operation.

B. **Air-Vacuum Valves.** Shall be designed to automatically permit the rapid egress of large amounts of air from the pipeline while the pipeline is being filled with water, and to permit the rapid ingress of large amounts of air into the pipeline while the pipeline is being emptied.

C. **Air Release Valves.** Shall be designed to automatically permit the escape of small amounts of accumulated air from pipelines operating under pressure.

D. **Combination Air-Vacuum and Air Release Valves.** Shall be designed to automatically operate as described above for air-vacuum valves and air release valves.

### 2.03 SYSTEM AIR VALVES

Air valves for use in distribution systems shall be the float and lever type of the makes listed herein, or equal as approved by the Engineer:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Sizes</th>
</tr>
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<tbody>
<tr>
<td><strong>Air Release Valves</strong></td>
<td></td>
</tr>
<tr>
<td>Apco #65</td>
<td>3/4&quot;</td>
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<tr>
<td><strong>Air Release &amp; Vacuum Valves</strong></td>
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<tr>
<td>Apco 143-C</td>
<td>1&quot;</td>
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<tr>
<td>Apco 145-C</td>
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<td>Valmatic 201-C</td>
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<tr>
<td>Crispen U-10</td>
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<tr>
<td>Crispen U-20</td>
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</tr>
<tr>
<td>Apco 149-C</td>
<td>4&quot;</td>
</tr>
<tr>
<td>Apco 150-C</td>
<td>6&quot;</td>
</tr>
</tbody>
</table>

### 2.04 PUMP AIR VALVES

All air release valves for use on pumps shall have 3/4" pipe connection and shall be Armstrong Machine Works No. 21 AR Air Relief Trap, or equal as approved by the Engineer.

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SECTION 15260
DUCTWORK THERMAL INSULATION

PART 1 - GENERAL

1.01 DESCRIPTION

A. SCOPE:

This section specifies thermal insulation for the exterior of metal air ductwork systems in outdoor applications.

B. TYPE:

External ductwork insulation shall be the flexible blanket type and have a reinforced foil kraft vapor barrier facing.

1.02 QUALITY ASSURANCE

A. EXTERNAL DUCTWORK INSULATION:

External ductwork insulation shall be designed to comply with the following:

1. Thickness, inches 1-1/2
2. Temperature range, degrees F 40-250
3. Density, pounds per cubic foot 0.75
4. Moisture absorption, percent by volume 0.20
5. Thermal conductivity, Btu inches per hour per sq ft per degree F (based on mean temperature of 75 degrees F) 0.30

1.03 SUBMITTALS
Submittals shall be provided in accordance with Section 00100 SC-16 and shall include the following information:

1. A copy of this specification section, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation.

2. Catalog data, including thicknesses and materials of construction.

1.04 ENVIRONMENTAL CONDITIONS:

The insulation to be provided under this section shall be suitable for continuous services in heating, ventilating, and air conditioning ductwork.

Outdoor external insulation shall be suitable for continuous service on the outside of ductwork in weather-exposed locations.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

The Owner and Engineer believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement however shall not be construed as an endorsement of a particular manufacturer’s products, nor shall it be construed to mean that named manufacturers’ standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include Knauf, Johns Manville, Owens Corning Fiberglass, or equal.

2.02 EXTERNAL DUCTWORK INSULATION

External insulation shall be made from long, extremely fine, flame attenuated glass fibers, bonded with a thermosetting resin. The facing shall be constructed out of reinforced foil kraft.
PART 3—EXECUTION

3.01 GENERAL

Duct to be insulated is the supply air duct from the evaporative cooler through the wall penetration.

3.02 EXTERNAL DUCTWORK INSULATION:

External duct insulation shall be applied with edges tightly butted and shall be secured by applying 50 percent coverage (6-inch wide strips on 12-inch centers) of vapor barrier adhesive. All seams shall be sealed with 4-inch wide tape with the ends of the tape overlapping at least 4-inches. Where the underside of horizontal ducts exceeds 24 inches in width, insulation shall be additionally secured by mechanical fasteners such as speed clips and nail type stick clips fastened with adhesive. One mechanical fastener shall be used for every 2 square feet of duct surface. All duct penetrations shall be sealed with a piece of the same facing material as the duct and installed with the same vapor barrier adhesive. External insulation and vapor barriers shall extend through all duct sleeves.

END OF SECTION 15260
PART 1--GENERAL

1.01 DESCRIPTION

This section specifies plumbing fixtures, trim and fittings.

1.02 QUALITY ASSURANCE

A. WORK:

Work shall be in accordance with the California Plumbing Code.

B. REFERENCES:

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

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

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
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<tbody>
<tr>
<td>CPC</td>
<td>California Plumbing Code</td>
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1.03 SUBMITTALS
Submittals shall be provided in accordance with Section 00100 SC-16 and shall include the following information:

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

PART 2--PRODUCTS

2.01 LAVATORIES

A. COUNTER TOP MOUNTED:

Counter top mounted lavatories shall be vitreous china type, 19 inch diameter, with fitting ledge, front overflow, and 4-inch faucet openings. Lavatories shall be American Standard 0491.019, Kohler K-2201, or equal. Trim shall be American Standard 2103.786, Kohler K-7401-TL, or equal.

Lavatories shall be provided with chrome-plated strainer, tail piece, and tubular brass P-trap with flange.

B. WALL MOUNTED:

Wall mounted lavatories shall be vitreous china type, 20 inch x 18 inch, with front overflow and 4-inch faucet opening. Lavatories shall be American Standard 0124.024, Kohler K-1725, or equal. Trim shall be American Standard 2103.786, Kohler K-7401-TL, or equal.
Lavatories shall be provided with chrome-plated strainer, tail piece and tubular brass P-trap with flange.

2.02 SINKS

A. LABORATORY SINKS:

Laboratory sinks shall be as specified in Section 2.01.

B. KITCHEN SINKS:

Kitchen counter top sinks shall be of acid resisting enameled cast iron, 33 inch x 22 inch, with two compartments, fitting ledge, and three-hole drilling. Sinks shall be American Standard 7023.021, Kohler K-5943, or equal. Trim shall be American Standard 4150.132, Kohler K-7825-TL, or equal.

Sinks shall be provided with drain, strainer and stopper combination and shall be Elkay No. LK-99, Crane No. 8-5241, or equal.

Sinks shall be provided with tail piece and drain, chrome-plated P-trap, stops and supplies.

C. SERVICE SINKS:

Service sinks shall be acid resisting enameled cast iron, plain back with rim guard, 22 inch x 18 inch, and shall be wall hanger type. Sinks shall be American Standard 7692.023 with 8379.018 rim guard, Kohler K-6718, or equal. Trim shall be American Standard 8340.234, Kohler K-8907, or equal. Sinks shall be provided with chrome-plated strainer, wall mountings, and floor trap.

D. FLOOR SERVICE SINKS:

Floor service sinks shall be acid-resisting enameled cast iron and shall be corner type with vinyl coated rim. Floor sinks shall be American Standard 7740.020, Kohler K-6710, or equal. Sinks shall be provided with faucet with bucket hook, vacuum breaker, top brace, and stops in shanks.

Sinks shall be provided with chrome-plated strainer and rubber hose and hose holder. Hose and hose holders shall be American Standard 8344.111, Kohler K-8928, or equal.

2.03 TOILETS
Toilets shall be off-the-floor, elongated, siphon jet action, bowl type of vitreous china with 1-1/2-inch top spud. Toilets shall be American Standard 2477.016, Kohler K-4430ET, or equal. Toilets shall be provided with flush valves and seats. Seats shall be white Kohler K-4670C, Church 5321.112, or equal. Flush valves shall be Delany 402-AVB, Sloan Royal 110-FYV, or equal. Mounting brackets, anchorage, and hardware shall be provided.

2.04 URINALS

Urinals shall be vitreous china, wall-hung blowout type with flushing rim, 1-1/4-inch top spud, and 2-inch outlet. Urinals shall be American Standard 6570.014, Kohler K-5007T, or equal. Urinals shall be provided with flush valves and support brackets. Flush valves shall be Delany 452-HVB, Sloan Royal 180, or equal.

2.05 SHOWER FITTINGS

Shower fittings shall be American Standard 1204.320, Kohler K-7226-T with K-7371 shower head, or equal.

2.06 WASH FOUNTAINS

Wash fountains shall be semicircular, 36-inch diameter, 13-gage stainless steel bowl and pedestal with a No. 4 finish. Wash fountains shall be foot operated and shall drain and vent from below or through the wall. Wash fountains shall be provided with spray head, support tube, spud and strainer, foot valve, operating mechanism, foot levers and rail, mixing and volume control valves, soap dispenser, stop, strainer and check valves.

2.07 PRODUCT DATA

Manufacturer's catalog data shall be provided in accordance with Section 01300.

PART 3—EXECUTION

Fixtures shall be provided plumb and level.

Fixtures shall remain in manufacturer's packaging until installation.

Fixtures shall be provided with required holes for fittings and mounting hardware. Unoccupied fixture faucet holes are not acceptable. Exposed fixture setting bolts shall be fitted with china caps.
Fixtures shall be supported in accordance with manufacturer's recommendations. Wall mounted fixtures shall be provided with brackets and anchorage. Drop-eared fittings shall be provided at fixture outlets and securely fastened to backing.

Openings into pipes shall be capped during construction.

Vitreous finished surfaces on lavatories, toilets, and sinks shall have heavy paper pasted thereon during construction.

END OF SECTION 15440
SPECIFICATIONS - DETAILED PROVISIONS
Section 15700 - Heating, Ventilation, and Air Conditioning Equipment

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PART 1 - GENERAL

1.01 DESCRIPTION

The Contractor shall furnish, install, and test the heating, ventilation, and air conditioning (HVAC) equipment including ducts, registers, louvers, supply and exhaust ventilators, evaporative coolers, air conditioners, dampers, thermostats, controls and accessories as specified herein and shown on the Drawings.

1.02 SPECIFIC PROJECT VENTILATION AND AIR CONDITIONING REQUIREMENTS

Contractor shall furnish and install specific project HVAC equipment as shown on the Drawings and as specified in Section 15700.1, Detailed Heating, Ventilation and Air Conditioning Equipment.

1.03 GENERAL REQUIREMENTS

A. Ambient Conditions and Elevations

Equipment shall be designed to operate at the elevation and ambient conditions shown on the Drawings and specified in the Special Conditions.

B. Dimensional Restrictions

Layout dimensions will vary between manufacturers. The layout area indicated on the Drawings is based on typical equipment. Contractor shall review the Contract Drawings, the manufacturer's layout drawings, and installation requirements and shall make any modifications required for proper installation subject to acceptance by the District.

C. Coordination

Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the Drawings, Specifications, and recommendations of the equipment manufacturer. Contractor shall verify that each component of the system is compatible with all other parts of the system; that all piping, ductwork, materials, equipment, and motor sizes are appropriate; and that all devices necessary for a properly functioning system have been provided.
D. Manufacturers and Local Service

Where two or more units of the same class of equipment are required, they shall be the product of a single manufacturer. However, all the component parts of the system need not be the products of one manufacturer.

Each equipment manufacturer shall have a local service center and shall be able to provide service within 24 hours. The service center shall be equipped and staffed to service the system and shall maintain a local parts supply. Information on equipment manufacturers' representatives shall be included with the submittals.

1.04 SUBMITTALS

A. Shop Drawings

In accordance with the requirements of the General Conditions, Contractor shall submit complete information, drawings, and technical data for all equipment and components, including, but not limited to, the following:

1. Complete specifications, dimensioned drawings of each equipment unit and support curb (if applicable), catalog cuts, data sheets, bill or materials, and descriptive literature which shall include make, model, dimensions, weight of equipment, and electrical schematic wiring diagrams (if applicable).

2. Details of unit support and anchorage requirements.

3. Complete performance data, performance curves, and ratings that will indicate full compliance with the specifications.

4. Control components, including description of control component operations. Equipment wiring diagrams and interconnection diagrams.

5. Detailed information on structural, mechanical, electrical, or other changes or modifications necessary to adapt equipment and materials to be supplied to the arrangement or details shown on the Drawings.

6. Shipping, unloading, storage, and installation instructions, lifting points, and any special precautions to be observed during unit storage and installation.

B. Operation and Maintenance Manuals

Operation and maintenance manuals shall be provided in accordance with the requirements of the General Conditions, and Detailed Provisions, Specification 01430.
PART 2 - PRODUCTS

2.01 GENERAL

A. Specific Project Requirements

Not all products specified herein are necessarily required for this project. Contractor shall refer to the Drawings and Item 1.02 "Specific Project Ventilation and Air Conditioning Requirements" herein for products required for this project. Said products shall be provided as specified herein and shown on the Drawings.

B. Equipment Manufacture and Fabrication

Manufacture and fabrication of equipment shall comply with the requirements of Section 11005, General Mechanical and Equipment Specifications.

C. Drive Units

Electric motors, V-belt drives, and safety guards shall be in accordance with the requirements of Section 11005, General Mechanical and Equipment and Section 16150 Induction Motors Specifications.

D. Electrical

Electric motor controls shall be as shown on the Drawings and as specified in Section 16480, Motor Control Centers, Switchboards, and Panelboards, Section 17005, General Instrumentation and Control Components, and Section 17010, Programmable Logic Controller. Motor starters and controls shall be furnished and installed as shown on the Drawings, except for equipment specified to be furnished with factory manufactured control panels.

E. Shop Testing

The equipment furnished under this section shall be tested at the factory according to the standard practice of the manufacturer. Ratings shall be based on tests made in accordance with applicable AMCA, ASHRAE, ARI, NBS, NFPA, and UL Standards.
F. Balance

All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that the resonance at normal operating speeds is avoided. In any case, the maximum measured root-mean-square (rms) value as measured at any point on the equipment shall not exceed those listed in the latest ASHRAE Applications Handbook.

At any operating speed, the ratio of rotative speed to the critical speed of a unit or components thereof shall be less than 0.8 or more than 1.3.

2.02 WALL LOUVERS

A. General

1. Louvers shall be intake or exhaust as shown on the drawings of the fixed (unless otherwise specified), flat blade, 45° type, having a width of 4" and sized to fit the opening specified.

2. Louvers shall be suitable for mounting in stud wall, with gypsum board and stucco, concrete walls, or masonry walls as shown on the Drawings. Size, number, and location shall be as shown on the Drawings.

3. Louvers shall be anchored into walls (from inside of building) at corners, top and side, and bottom and side with wood lag screws or expansion anchors as applicable. Additional anchors shall be provided such that maximum anchorage space shall be 24" O.C.

4. Louvers shall be weatherproofed. All louver edges, including flashing, in contact with wall surfaces shall be caulked with exterior grade caulking compound.

B. Wall Mounted Stationary (Fixed) Louvers

1. Fixed blade (stationary) intake or exhaust louvers shall be flat blade type of formed steel with blades at 45° angle. Frame and blades shall be minimum 16 gauge galvanized steel.

2. Each louver shall be provided with a removable 1/4" mesh, 23 gauge wire, galvanized insect screen with galvanized steel frame. Screen shall be attached with screws. Screen shall be located on interior side of wall.
3. Stationary wall louvers shall be Model 609B as manufactured by The Airolite, Co., or equal.

C. Wall Mounted Adjustable Louver

1. Adjustable blade intake or exhaust louvers shall be of formed steel construction with frame and blade minimum 18 gauge galvanized steel.

2. Blades shall be positioned at 45° when fully opened. Crank handle shall be provided for adjusting and shall be provided with an extension where wall thickness necessitates.

3. Each louver shall be provided with a removable 1/4" mesh, 23 gauge wire, galvanized insect screen with galvanized steel frame. Screen shall be attached with screws. Screen shall be located on interior side of wall.

4. Adjustable wall louvers shall be Model AEL-162 as manufactured by Louvers & Dampers, Inc., or equal.

5. Where shown on the Drawings or specified herein, adjustable louvers shall be provided with electric motor actuators. Actuators shall be operated by 120 VAC power and shall be provided with spring return to fully open or fully closed as specified.

6. Where shown on the Drawings or specified herein, adjustable louvers shall be recessed in the wall and be provided with a vandal protection type louver on exterior.

D. Wall Mounted Automatic Gravity Type Louvers

1. Intake and exhaust automatic gravity type louvers shall be suitable for high velocity and high static pressure and shall automatically open upon operation of the ventilation system or radiator cooling exhaust fan. Louver shall be intake or exhaust as shown on the Drawings and dictated by the ventilation system. Louvers shall consist of 16 gauge galvanized formed steel frame and 14 gauge aluminum tied blades with felt tip edges. Automatic gravity type louvers shall be as manufactured by Louvers & Dampers, Inc., or equal.

2. Intake and exhaust openings shall be provided with weather protection fixed louvers on exterior face and the gravity louvers on the interior face unless otherwise specified.
E. Wall Mounted Acoustical Louver

1. Formed steel acoustical wall louvers shall be provided where specified or shown on the Drawings. Construction shall be similar to fixed wall louvers. Noise side of louver shall include Type 703 fiberglass at 3.0 lb/cu ft density covered with 20 gauge perforated galvanized steel, or equal. Minimum noise reduction of 14 dB at octave band No. 3 shall be provided.

2. Each louver shall be provided with a removable 1/4" mesh, 23 gauge wire, galvanized insect screen with galvanized steel frame. Screen shall be attached with screws. Screen shall be located on interior side of wall.

3. Acoustic louver shall be 8" thick Model ALC-8-101 as manufactured by Louvers & Dampers, Inc., or equal.

2.03 SHEET METAL DUCTWORK AND MISCELLANEOUS ACCESSORIES

A. Construction

1. Ductwork (ducts and fittings) shall be constructed as shown on the Drawings with airtight joints and seams in accordance with ASHRAE standards and SMACNA Duct Construction Manual. Unless specified otherwise, ductwork shall be fabricated per SMACNA low pressure class, with static pressure rating of 2" w.g. (positive or negative) and suitable for air velocities of up to 2,500 fpm. Ductwork materials shall be galvanized steel per ASTM A527 with coating designation G-90, unless otherwise specified. Minimum duct gauges required are as follows:

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<tr>
<th>Maximum Size of Ducts</th>
<th>Galvanized Steel U.S. Standard Gauge</th>
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<td>12&quot; and less</td>
<td>24</td>
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<tr>
<td>13&quot; through 30&quot;</td>
<td>22</td>
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<td>31&quot; through 54&quot;</td>
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2. All transverse joints shall be sealed per SMACNA Class C requirements with vinyl acrylic duct sealant, nonflammable wet or dry, UL listed, with flame spread O, fuel contributed O, and smoke developed O. Gaskets for flanged duct joints shall be 1/4" thick, full faced, closed cell, expanded neoprene sponge.
B. **Supports**

Supports for horizontal ducts shall be galvanized steel angles or double struts with threaded hanger rods unless specified otherwise. Supports for vertical ducts shall be band iron strap or angle bracket type. Inlet ducts shall be amply braced to withstand maximum negative pressure.

C. **Flexible Connectors**

1. Flexible duct connections shall be made at each point where the air conditioning or air handling unit is connected to a duct. Flexible connectors shall be UL listed, waterproof, fire resistant, mildew resistant, air-tight woven fibrous glass cloth, double coated with chloroprene or chlorosulphonated polyethylene, and provided with sheet metal collars. Flexible connectors shall be as manufactured by Ventfabrics, Inc., United McGill, Duro-Dyne Ductmate.

2. Fabric for flexible connections protected from sunlight and the weather shall be suitable for a temperature range of -20 to 180°F and shall weigh at least 27 ounces per square yard.

3. Fabric for flexible connections exposed to sunlight or the weather shall be suitable for a temperature range of -10 to 250°F and shall weigh at least 24 ounces per square yard.

D. **Volume Control Dampers**

Where shown on the Drawings, provide factory fabricated volume control dampers with locking quadrant and 8" maximum blade width. Volume control dampers shall be Ruskin MD-25 or MD-35 (rectangular), MDRS-25 (round), or equal. Dampers shall be manually adjusted for air balancing.

E. **Insulation and Weatherproofing**

1. All exterior ductwork shall be provided with an insulation and weatherproofing system suitable for outdoor conditions, including direct sunlight and rain. The insulation system shall be installed in strict accordance with the manufacturer's printed recommendations.
2. Insulation material shall be a flexible, closed-cell, 1” thick (minimum) elastomeric insulation in sheet form. The insulation material shall be AP Armaflex SA, as manufactured by Armacell. Insulation material shall have a maximum thermal conductivity of 0.28 BTU-in/hr-sq ft-deg-F at 90°F. Insulation material shall have a flame-spread index of less than 25 and a smoke-developed index of less than 50.

3. Adhesive shall be a contact adhesive, Armaflex 520 as manufactured by Armacell.

4. Sheet insulation shall be adhered directly to clean, oil-free duct surfaces with a full coverage of contact adhesive. The duct insulation shall be constructed from the bottom up, with the top insulation sized to extend over the side insulation to form a watershed. Butt-edge seams shall be adhered using contact adhesive by the compression fit method to allow for expansion/contraction. Standing metal duct seams shall be insulated with the same insulation thickness as installed on the duct surface. Seams shall be covered using strips of sheet insulation. Standing seams shall be adhered using contact adhesive. Insulation seams shall be staggered when applying multiple layers of insulation.

5. All insulated ductwork shall be weatherproofed with 0.020" thick stucco-embossed aluminum jacketing. Jacketing shall be manufactured from ASTM B-209, Temper H-14 aluminum alloy with factory bonded moisture barrier. Aluminum jacketing shall be installed with a 2" overlap at longitudinal seams and end joints. Secure jacket with stainless steel sheet metal screws at 6" on center along seams and at end joints. Overlapped longitudinal seams shall be arranged to shed water. All joints shall be sealed with a silicone mastic to provide a continuous weather-tight joint. Strapping shall be 3/4" wide aluminum or stainless steel. Aluminum jacketing shall be as manufactured by Pabco Childers Metals, RPR Products, Inc., or equal.

2.04 SUPPLY AND RETURN REGISTERS

A. General

Supply and return registers shall be constructed of Type 304 stainless steel. Unless specified otherwise, supply registers shall be double deflection with front deflection blades parallel to the short dimension of the register and return registers shall be single deflection with deflection blades parallel to the short dimension of the register. Registers shall be as manufactured by Titus, A-J Manufacturing Co., or equal.
B. **Construction**

1. Registers shall be provided with a 1-1/4" wide border on all sides for flush surface mounting. Borders shall be provided with continuous foam gaskets. Screw holes shall be countersunk for a neat appearance. Corners shall be welded with full penetration resistance welds. Where registers are shown to be mounted in exposed ductwork, register frames shall not extend beyond the sides of the ductwork. Register manufacturer shall coordinate register size and mounting with ductwork manufacturer.

2. Deflection blades shall be contoured and spaced on 3/4" centers. Blades shall have friction pivots on both ends to allow individual blade adjustment without loosening or rattling. Plastic blade pivots are not acceptable.

3. Each register shall be provided with an opposed blade volume damper constructed of heavy gauge Type 304 stainless steel. Damper shall be operable from face of register.

4. Registers shall be unpainted and furnished with a uniform satin (mill) finish.

### 2.05 ROOF MOUNTED EXHAUST VENTILATORS, LOW PROFILE TYPE WITH HOOD

A. Roof exhaust ventilators shall be of low profile design with extruded aluminum hood of the centrifugal, belt-driven type. Construction of the fan housing shall be of heavy gauge aluminum.

B. The fan wheel shall be all-aluminum of the centrifugal blower type featuring backward inclined blades and a tapered inlet shroud. Wheels shall be statically and dynamically balanced.
C. Motors shall be of the heavy duty, permanently lubricated, sealed ball bearing type. Drives shall be sized for 165% of motor horsepower capabilities and of the cast iron type, keyed to the fan and motor shafts. Variable pitch drives shall be standard. Fan shaft shall be of steel construction, turned, ground, and polished to precise tolerances in relationship to the hub and bearings. Drive belts shall be of the oil-resistant, non-static, non-sparking type with life expectancy of over 24,000 hours. Bearings shall be flanged and of the permanently lubricated, permanently sealed, ball bearing type capable of over 200,000 hours bearing life. The entire drive assembly and wheel shall be removable, as a complete unit, from the support structure without disassembling the external fan housing. The complete drive assembly shall be mounted on rubber vibration isolation. Direct drive units shall be of identical construction as belt drive units, except for drives, belts, and fan shaft bearings. Fans shall be licensed to bear the AMCA ratings seal for air and sound performance. Motor voltage and phase shall be as shown on the Drawings and as specified in Part 1.02 herein.

D. Fans shall be Model HLC-B as manufactured by Loren Cook, Model LD/LB as manufactured by Greenheck, or equal. Each fan shall have the performance as specified in Part 1.02 herein.

E. Unless shown otherwise on the Drawings, roof exhaust ventilators shall be mounted on prefabricated metal roof curbs. Prefabricated roof curbs shall be a minimum 8" high, constructed of minimum 18-gauge galvanized steel, with 2" x 2" treated wood nailer, 1" (minimum) semi-rigid thermal insulation, and 3" x 3" integral cant. Exhaust ventilators shall be installed level on pitched roofs, and roof curbs shall be sized to accommodate the roof pitch shown on the Drawings. Prefabricated roof curbs shall be model SC as manufactured by Louver & Dampers, Inc., or equal. Ventilators shall be provided with automatic gravity backdraft dampers.

2.06 ROOF MOUNTED EXHAUST VENTILATORS, DOWNBLAST TYPE

A. Downblast type exhaust ventilators shall be roof-mounted with a belt-driven centrifugal fan wheel. Fan enclosure shall be spun aluminum, mushroom style.

B. Centrifugal fan wheel shall be backward inclined, aluminum construction. Wheel shall be balanced in accordance with AMCA Standard 204-96, Balance Quality and Vibration Levels for Fans.

C. Aluminum enclosure structural components shall be constructed of minimum 16 gauge marine alloy aluminum and shall be bolted to a rigid aluminum support structure. Aluminum base shall have continuously welded curb cap corners. The motor shall be enclosed in a weather-tight compartment, separated from the exhaust airstream.
D. Motors shall be of the heavy duty, permanently lubricated, sealed ball bearing type. Drives shall be sized for 150% of motor horsepower capabilities and of cast iron construction. Bearings shall be heavy duty regreasable ball type in a cast-iron pillowblock housing selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed. The motor, bearings, and drives shall be mounted on a minimum 14-gauge steel power assembly, isolated from the unit structure with rubber vibration isolators. Fan shaft shall be of steel construction, turned, ground, and polished to precise tolerances in relationship to the hub and bearings. Motor voltage and phase shall be as shown on the Drawings and as specified in Part 1.02 herein.

E. Fans shall be Type ACE as manufactured by Loren Cook Company, Type GB as manufactured by Greenheck, or equal. Each fan shall have the performance as specified in Part 1.02 herein.

F. Unless shown otherwise on the Drawings, roof exhaust ventilators shall be mounted on prefabricated metal roof curbs. Prefabricated roof curbs shall be a minimum 8" high, constructed of minimum 18-gauge galvanized steel, with 2" x 2" treated wood nailer, 1" (minimum) semi-rigid thermal insulation, and 3" x 3" integral cant. Exhaust ventilators shall be installed level on pitched roofs, and roof curbs shall be sized to accommodate the roof pitch shown on the Drawings. Prefabricated roof curbs shall be model SC as manufactured by Louver & Dampers, Inc., or equal. Ventilators shall be provided with automatic gravity backdraft dampers.

2.07 RESTROOM CEILING EXHAUSTER

A. Contractor shall furnish and install restroom exhausters as specified herein and as shown on the Drawings. Exhausters shall be ceiling mount type, direct driven, UL listed, centrifugal exhaust fans.

B. Fan housing shall be minimum 20 gauge galvanized steel and acoustically insulated. Blower and motor assembly shall be mounted to a minimum 14 gauge reinforcing channel and shall be easily removable from the housing. Motor shall be mounted on rubber vibration isolators. Unit shall be supplied with integral wiring box and receptacle. The outlet duct collar shall include a reinforced aluminum damper with continuous aluminum hinge rod and brass bushings. Inlet shall be provided with an aluminum grill.

C. Blower wheel shall be centrifugal forward curve type, constructed of galvanized steel. Wheel shall be balanced in accordance with AMCA Standard 204-96.

D. Motor shall be open drip-proof type with permanently lubricated sealed bearings and built-in thermal overload protection.
E. Fans shall be Gemini GC type as manufactured by Loren Cook, or equal.

F. Unless shown otherwise on the Drawings, ceiling exhausters shall be provided with hanging isolator hardware, including all-thread rods, isolator bushings, and appurtenances.

2.08 PAD MOUNTED AIR CONDITIONING UNIT

A. A commercial pad mounted packaged air conditioning unit shall be provided for room cooling as shown on the Drawings. Air conditioning unit shall be factory assembled, piped, internally wired, and fully charged. Unit shall be UL listed and carry UL label. Unit shall be factory run tested to check cooling operation, fan and blower rotation, and control sequence. Unit shall be designed for pad mounted installations.

B. The packaged unit shall be a 1-phase, 230V (or 3-phase, 460V) 60 Hz horizontal airflow model as required per Part 1.02 herein, and shall be rated for a minimum total cooling capacity as specified in Part 1.02, with a minimum Seasonal Energy Efficiency Ratio (SEER) of 13. Packaged unit shall be equipped with the following components: compressor, refrigerant circuit, indoor/outdoor coil and fan, return air filter and frame, and system controls.

C. All components shall be mounted in a galvanized steel cabinet with a baked-on enamel finish. Access panels, removable top cover, knockouts for utility and control connections, and coil guards shall be a part of the cabinet.

D. Coils shall be constructed with aluminum fins mechanically bonded to internally grooved copper tubes. Coils shall be provided with a balanced port thermal expansion valve to provide optimal performance over the application range. Coils shall be pressure and leak tested to 450 psig. An epoxy modified, phenolic dip coating shall be provided for enhanced corrosion protection.

E. The compressor shall be a hermetically sealed, high efficiency compressor with internal pressure relief and internal over-current and over-temperature protection. Motors for indoor air and outdoor fans shall be permanently lubricated and have built-in thermal overload protection. Indoor air fan (blower) shall provide a minimum air flow (cfm) as specified in Part 1.02 herein.
F. The air conditioning unit shall be as manufactured by Trane, or equal. The air conditioning unit shall be provided with the following accessories: internal filter frame and pleated air filter (air filter clean resistance per manufacturer's recommendations), standard indoor thermostat as recommended by manufacturer, and a NEMA 3R, 240V, 1-phase or 480V, 3-phase (per Part 1.02 herein) air conditioning fused disconnect switch with 120V, 1-phase, GFI receptacle. A minimum of three (3) spare air filters shall be furnished for each air conditioner.

G. The air conditioning unit shall be installed in accordance with the manufacturer's printed installation instructions. Electrical connections to the unit shall be made with flexible liquid-tight conduit and weather-tight fittings. Condensate drain piping shall be copper and be fabricated with a trap and cleanout plug. Disconnect switch shall be mounted on the air conditioning unit. The unit shall be anchored to the concrete support slab with vibration isolation pads and Type 316 stainless steel anchors (size and embedment per air conditioning unit manufacturer).

H. Contractor shall coordinate selection of packaged unit and accessories with associated supply/return ductwork to provide a complete and operable air conditioning system.

2.09 PAD MOUNTED HEAT PUMP UNIT

A. A commercial pad-mounted packaged heat pump unit shall be provided for room cooling/heating as shown on the Drawings, and as specified herein. Heat pump unit shall be factory assembled, piped, internally wired, and fully charged. Unit shall be UL listed and carry UL label. Unit shall be factory run tested to check cooling/heating operation, fan and blower rotation, and control sequence. Unit shall be designed for ground level installation.

B. The packaged heat pump shall be a 1-phase, 230V (or 3-phase, 460V), 60 Hz horizontal airflow model as required per Part 1.02 herein and shall be rated for a minimum cooling/heating capacity as specified in Part 1.02, with a minimum Seasonal Energy Efficiency Ratio (SEER) of 13. Packaged unit shall be equipped with the following components: compressor, refrigerant circuit, indoor/outdoor coil and fan, return air filter and frame, and system controls.

C. All components shall be mounted in a galvanized steel cabinet with a baked-on enamel finish. Access panels, removable top cover, knockouts for utility and control connections, and coil guards shall be a part of the cabinet.
D. Coils shall be constructed with aluminum fins mechanically bonded to internally grooved copper tubes. Coils shall be provided with a balanced port thermal expansion valve to provide optimal performance over the application range. Coils shall be pressure and leak tested to 450 psig. An epoxy modified, phenolic dip coating shall be provided for enhanced corrosion protection.

E. The compressor shall be a hermetically sealed, high efficiency compressor with internal pressure relief and internal over-current and over-temperature protection. Motors for indoor air and outdoor fans shall be permanently lubricated and have built-in thermal overload protection. Indoor air fan (blower) shall provide a minimum airflow (cfm) as specified in Part 1.02 herein.

F. The packaged heat pump unit shall be as manufactured by Trane, or equal. The packaged heat pump shall be provided with the following accessories: internal filter frame and pleated air filter (air filter clean resistance per manufacturer's recommendations), rubber vibration isolation pads, standard indoor thermostat, and a NEMA 3R, 240V, 1-phase or 480V, 3-phase, fused disconnect switch with 120V, 1-phase, GFI receptacle. A minimum of three (3) spare air filters shall be furnished.

G. The packaged heat pump shall be installed in accordance with the manufacturer's printed installation instructions. Electrical connections to the unit shall be made with flexible liquid-tight conduit and weather-tight fittings. Condensate drain piping shall be copper and be fabricated with a trap and cleanout plug. Disconnect switch shall be mounted on the packaged heat pump unit. The heat pump shall be anchored to the concrete support slab with vibration isolation pads and Type 316 stainless steel anchors (size and embedment per heat pump manufacturer).

H. Contractor shall coordinate selection of packaged unit and accessories with associated supply/return ductwork and structural roof framing and provide a complete and operable heat pump system.

I. Contractor shall provide volume control dampeners as necessary and also where shown on the Drawings to achieve air flow splits as specified.

2.10 WALL MOUNTED AIR CONDITIONING UNIT

A. A commercial wall mounted packaged air conditioning unit shall be provided for room cooling as shown on the Drawings. Air conditioning unit shall be factory assembled, piped, internally wired, and fully charged. Unit shall be Intertek ETL listed. Unit shall be factory run tested to check cooling operation, condenser fan and blower rotation, and control sequence. Unit shall be designed for wall mounting installation.
B. The packaged unit shall be a 1-phase, 230V, or 3-phase, 460V, 60 Hz horizontal airflow, through-wall, model and shall be rated for a minimum total cooling capacity as specified in Part 1.02 herein, with a minimum Energy Efficiency Ratio (EER) of 10.0. Packaged unit shall be equipped with the following components: compressor, blower assembly, condenser fan, phenolic epoxy coated condenser coil, phenolic epoxy coated evaporator coil, refrigerant circuit, return air filter and frame, and system controls.

C. All components shall be mounted in a weather-resistant galvanized steel cabinet (20-gauge minimum thickness) with a baked-on polyester enamel finish. Lower base shall be 16-gauge (minimum) galvanized steel. The cabinet shall be provided with a sloped top and rain flashing. The cabinet shall be provided with full length side mounting brackets that are integral to the cabinet frame. Cooling section shall be fully insulated with minimum 1" thick fiberglass. Access panels, removable top cover, knockouts for utility and control connections, and coil guards shall be a part of the cabinet.

D. The refrigeration system shall include a high efficiency scroll compressor, mounted on rubber pads. 3-phase compressors shall be provided with protection against phase reversal and phase failure that will prevent the compressor from operating when one of these conditions occurs. The refrigeration circuit shall be provided with factory installed high and low pressure controls and liquid line filter dryer. The refrigeration control shall be a factory installed capillary tube.

E. The condenser fan, motor, and shroud shall be configured for easy slide-out removal.

F. The indoor blower motor shall be high efficiency, permanent split capacitor (PSC) type. The blower motor shall be provided with protection against overload. Blower assembly shall include twin wheels with forward curve blades.

G. The control system shall include a current limiting low-voltage transformer, on and off time delay circuits to prevent rapid compressor short cycling, low pressure bypass to prevent nuisance tripping during low temperature startup, and one (1) alarm output relay.

H. The electrical control panel shall be configured for right-side or left-side access as specified in Part 1.02, herein.

I. When specified in Part 1.02 herein, or shown on the Drawings, packaged units shall be provided with factory installed electric resistance heaters (rating as specified). Heater shall include automatic safety limit and thermal cut-off controls. Packaged units with heaters shall be provided with a factory installed circuit breaker (230 VAC models) or rotary disconnect (460 VAC models). Circuit breakers and rotary disconnects shall be provided with a lockable, hinged access covers.
J. When specified in Part 1.02 herein, or shown on the Drawings, packaged units shall be provided with options and accessories, including barometric fresh air dampener, motorized fresh air dampener, commercial room ventilator, economizer, or energy recovery ventilator.

K. The air conditioning unit shall be provided with a NEMA 3R, 240V, 1-phase or 480V, 3-phase, fused disconnect switch with 120V, 1-phase, GFI receptacle.

L. The air conditioning unit shall be installed in accordance with the manufacturer's printed installation instructions. The packaged unit shall be wall mounted with Type 316 stainless steel anchors bolts (size and embedment per packaged unit manufacturer).

M. Electrical connections to the unit shall be made with flexible liquid-tight conduit and weather-tight fittings. Disconnect switch shall be mounted on air conditioning unit or alternately mounted on adjacent building wall.

N. Contractor shall coordinate selection of packaged unit and accessories with associated supply/return ductwork to provide a complete and operable air conditioning system.

O. The packaged unit shall be provided with a 5 year parts warranty.

P. The wall mounted packaged air conditioning unit shall be Series WAA (right-side control panel) or WLA (left-side control panel) as manufactured by Bard, or equal.

2.11 EVAPORATIVE COOLER

A. A commercial self-contained horizontal discharge, single housing, direct evaporative cooler, including fan section, media, water delivery system, and necessary appurtenances shall be provided for room cooling as shown on the Drawings, and as specified herein.

B. The direct evaporative cooler shall be the wet pad, recirculating type suitable for connection to duct system or for through wall installation.

C. Evaporative coolers and accessories shall be designed to operate continuously. Each complete unit shall be AMCA certified in conformance with AMCA Standard 210. Certified performance data for all evaporative coolers shall be obtained from tests made in AMCA-approved laboratories.

D. Outside air shall be drawn through the wet evaporative cooler with the air handling unit supply fan. The cooler shall be located within the air handling unit downstream of an intake filter and a heating coil and upstream of the supply fan. A pump shall circulate water through the cooler.
E. The packaged unit shall be 1 phase, 230V (or 3 phase, 460V) 60 Hz, horizontal air flow model as required per Part 1.02 herein, and shall be rated for minimum air flow, static pressure, media face velocity and media evaporation efficiency.

F. Housing for the entire unit shall be constructed of Type 316 stainless steel in one piece with steel support frame and lifting lugs. Hinged access panels shall allow for access and removal of all internal components from a single side. Casing shall be insulated with 1 inch of 1-1/2-pound per cubic foot density neoprene coated NFPA-90 approved acoustical fiberglass insulation.

G. The fan section shall have a horizontal discharge with a flange or other provision to connect sheet metal ductwork as shown on the Drawings. The fan shall be centrifugal type with lubricable bearings on each end. Fan motor shall be totally enclosed fan cooled type and shall be sized to be non-overloading on all parts of the fan curve. Fan shall be belt-driven with adjustable sheave on the motor. Manufacturer’s standard vibration isolators shall be provided under the fan and motor, and neoprene flex connectors shall be provided between the fan discharge and the cabinet.

H. The wet section of the evaporative cooler shall be welded or mechanically attached to the fan section and shall be supported across its entire width by same support frame. Internal components of the wet section shall include the cooling media, water delivery system, internal plumbing, make-up water valve, overflow, and drain fittings.

I. The sump shall be stainless steel, leak-proof with welded corners and joints. A media support channel shall extend across the full width of the media and provide for water to flow from the media into the sump. Sump shall be provided with stainless steel couplers for connecting make-up water, overflow, and drain.

J. An air bypass inhibitor plate shall be provided between the media and the sump to prevent any untreated air flow under the media.

K. The water distribution system shall include a recirculating pump with mechanical float valve assembly to maintain water level in the sump. An adjustable bleed-off system with metering valve and all required piping and valves shall be provided. The internal plumbing shall include a PVC Schedule 80 header pipe with drilled orifice holes to spray water upward to a stainless steel splash plate that evenly distributes the water over the cooling media. A PVC union shall be provided in the riser pipe below the header to facilitate removal of the header pipe.
L. Cooling media shall be rigid, 12-inch deep modules of cellulose evaporation material. Modules shall have at least 120 square feet of evaporative surface area per cubic foot of media. Media shall develop a saturation efficiency of not less than 90 percent and a maximum air pressure drop of 0.315 inches water column at 500 feet per minute face velocity.

M. Power to the packaged unit shall be through a single feed and a fused disconnect located on the housing, and a starter and separate relay to control water distribution. Hand-Off-Auto switch and pilot lights shall also be mounted on the housing in a NEMA 3R enclosure.

N. The evaporative cooler shall be controlled by the room air handling unit thermostat. On a high temperature signal from the thermostat, the unit’s automatic fill and drain kit shall fill the sump tank and begin the spraying and evaporation. When room temperature drops to the low set point on the thermostat, the unit’s automatic fill and drain kit shall drain the sump tank allowing the evaporative media to dry. The automatic fill and drain kit shall consist of two solenoid valves, fill and drain switch, time clock, and freeze stat.

O. Evaporated cooler shall be manufactured by Premier Industries, Bessamaire, or equal.

2.12 SPLIT-DUCTLESS AIR CONDITIONING SYSTEM

A. A split-ductless air conditioning system shall be provided for room cooling as shown on the Drawings. Air conditioning system components shall be factory assembled, piped, internally wired, and fully charged. The air conditioning system shall be Intertek ETL listed. The air conditioning system shall be factory run tested to check cooling operation, operation of internal components, and control sequence.

B. The air conditioning system shall be a 1 phase, 230 volt, 60 Hz system and shall be rated for a minimum total cooling capacity as specified in Part 1.02, herein. The air conditioning system shall be provided with a single indoor unit or multiple indoor units as specified in Part 1.02, herein, or as shown on the Drawings. When specified herein or shown on the Drawings, the air conditioning system shall be provided with a heat pump system (each indoor unit) rated for a minimum total heating capacity as specified in Part 1.02, herein.

C. The air conditioning system shall have a minimum Seasonal Energy Efficiency Ratio (SEER) of 14.0.
D. The air conditioning system shall be equipped with the following components: floor mounted outdoor unit, wall mounted or ceiling suspended indoor unit(s), refrigerant piping between the indoor and outdoor unit(s), control wiring between the indoor and outdoor unit(s), condensate drain piping for indoor unit(s) to outside of building, and wired wall mounted controller(s).

E. **Outdoor Unit**

1. The outdoor unit shall include a direct drive propeller fan(s), fan motor (one (1) motor per fan), factory pressure tested heat exchanger (condenser) coil, compressor, refrigerant accumulator on the suction side of the compressor, control circuit board, wiring, and piping. Air shall discharge horizontally form the outdoor unit.

2. The coil shall be constructed with lanced or corrugated aluminum plate fins attached to copper tubing.

3. The fan shall be provided with permanently lubricated shaft bearings.

4. Refrigerant flow between the outdoor unit and indoor unit shall be regulated by an electronically controlled expansion valve. One (1) valve shall be provided for each indoor unit. Branch box(es) shall be provided as required by the manufacturer for housing the expansion valve(s) external to the outdoor unit.

5. The compressor shall be hermetically sealed, inverter driven, variable speed, and dual rotary type. The compressor shall be provided with internal thermal overload protection and mounted on vibration isolation pads.

6. The outdoor unit shall be capable of monitoring ambient temperature, condenser coil temperature, and refrigerant discharge temperature.

7. The outdoor unit enclosure shall be a weather-resistant bonderized galvanized steel cabinet with an electrostatically applied, thermally fused polyester coating. All assembly hardware shall be weather-resistant and enclosure shall be provided with integral mounting feet.
F. Indoor Unit(s)

1. Each indoor unit shall include a line-flow or double inlet forward curve radial fan(s) direct driven by a single fan motor, factory pressure tested heat exchanger (evaporator) coil, easily removable return air filter, corrosion resistant condensate drain pan, control circuit board, wiring, and piping housed in a high strength molded plastic or corrosion resistant coated metallic enclosure. Air shall discharge horizontally from the indoor unit(s).

2. The coil shall be constructed with smooth aluminum plate fins attached to copper tubing.

3. The fan(s) shall be statically and dynamically balanced and provided with a permanently lubricated shaft bearing. The fan(s) shall be capable of operating at a minimum of three (3) selectable fixed speeds or operating in automatic (automatically vary speed).

4. Each indoor unit shall include motorized, multi-position horizontal louvers to adjust air flow up and down, and manually or motorized adjustable vertical vanes to adjust air flow left and right.

5. Each indoor unit shall have a self-diagnostic function, time delay start function, and auto restart function after power interruption. Each indoor unit shall be capable of monitoring indoor room temperature and evaporator coil temperature.

6. Each indoor unit shall be purged with dry air in the factory prior to shipment.

7. Each indoor unit shall be powered directly from the outdoor unit.

G. Contractor shall coordinate selection of indoor unit(s) and outdoor unit to provide a complete and operable air conditioning system.

H. Contractor shall install all interconnection control and power wiring between the indoor and outdoor units (and branch boxes if applicable) as required to provide a complete functioning air conditioning system. The control wiring shall be provided by the manufacturer of the air conditioning system to ensure unit compatibility.

I. Contractor shall install all interconnection refrigerant piping between the indoor and outdoor units as required to provide a complete functioning air conditioning system. The refrigerant piping shall be annealed, refrigeration grade, seamless, copper tubing, AC/R type, meeting the requirements of ASTM B280. The refrigeration piping shall be provided with insulation meeting the requirements of Part 2.03E, herein.
J. Contractor shall install 3/4 inch diameter condensate drain lines from indoor unit(s) to the exterior of building. Unless specified otherwise, condensate drain lines shall be constructed of Schedule 40 PVC. Condensate drain lines shall be installed with 2% minimum slope towards drain point and said points shall be located 6 inches above the outdoor finished grade. Condensate drain lines shall be supported by strut channel type pipe supports.

K. The indoor and outdoor units shall be installed in accordance with the manufacturer's printed installation instructions. All mounting hardware shall be Type 316 stainless steel. Size and embedment of anchor bolts for outdoor units and wall mounted indoor units shall be determined by the manufacturer.

L. Where interconnection control and power wiring, interconnection refrigerant piping, and condensate drain piping penetrate building walls, Contractor shall provide rubber sleeves through wall penetrations and seal said penetrations with silicone sealant after installation of wiring and piping. Contractor shall provide Diversitech PVC split channel type ducts, or approved equal.

M. The air conditioning system shall be provided with a NEMA 3R, 240V, 1-phase fused disconnect switch with 120V, 1-phase GFI receptacle mounted adjacent to the outdoor unit.

N. The air conditioning system shall be provided with a 5 year parts and defects warranty and the compressor shall have a 7 year warranty.

O. Split-ductless air conditioning system shall be M-Series or P-Series as manufactured by Mitsubishi Electric, or equal.

**PART 3 - EXECUTION**

**3.01 GENERAL**

A. Contractor shall examine all equipment and material upon arrival at jobsite and determine that it is as specified and approved, and that it is new and in undamaged condition. Contractor shall verify openings (existing and/or new) in structures and ducts are of suitable size for equipment delivered. Contractor shall install all equipment, ductwork, fittings, and appurtenances in strict accordance with manufacturer’s printed instructions and approved shop drawings.
B. Contractor shall connect all necessary electrical power including furnishing of all necessary materials in addition to that included in the specified equipment. Wiring materials and installation shall be in accordance with Section 16050, Basic Electrical Materials and Methods, and controls and instrumentation in accordance with Section 17005, General Instrumentation and Control Components, and as shown on the Drawings.

C. Prior to equipment operation, Contractor shall provide initial lubrication of all mechanical systems, check all belts, pulleys, and other moving parts for alignment and tolerances in accordance with the manufacturer's operating instructions.

3.02 START-UP AND INSTRUCTION

A. Contractor shall arrange for qualified representatives of the manufacturer to inspect the installation and perform start-up of the equipment and to demonstrate required performance to the satisfaction of the District. As a minimum, manufacturer shall field measure air flow rates and specific pressures for each ventilator and air conditioning unit at each operating speed. Manufacturer shall also measure ventilator and air conditioning unit motor amperage, voltage, and power factor for each operating condition. Manufacturer shall furnish all labor and equipment required for field testing and furnish testing results to District in a written report.

B. Contractor shall balance the ventilation and air conditioning systems by adjusting louvers or grills (unless fixed louvers or grills are specified) to obtain even air flow across a room. Contractor shall furnish calibrated (certification required) air velocity meters for such balancing.

C. After the equipment has been installed, tested, and adjusted, and placed in satisfactory operating condition, the equipment manufacturer shall provide classroom instruction to District's operating personnel in the use and maintenance of the equipment. Two (2) hours of instruction shall be provided, unless otherwise specified. Contractor shall give the District formal written notice of the proposed instruction period at least two weeks prior to commencement of the instruction period. Scheduled training shall be at a time acceptable to the District and the manufacturer. During this instruction period, the manufacturer shall answer any questions from the operating personnel. The manufacturer's obligation shall be considered ended when he and the District agree that no further instruction is needed.

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PART 1 - GENERAL

1.01 DESCRIPTION

A. SCOPE:

This section specifies a self-contained, single housing, direct evaporative cooler, including fan section, media, water delivery system, and necessary appurtenances.

B. TYPE:

The direct evaporative cooler shall be the wet pad, recirculating type suitable for modular installation in air handling units.

C. EQUIPMENT LIST:

<table>
<thead>
<tr>
<th>EQUIPMENT NO.</th>
<th>AREA SERVICED</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC-1</td>
<td>Pump room</td>
</tr>
</tbody>
</table>

D. REFERENCE SPECIFICATIONS:

The general requirements applicable to all mechanical equipment, as specified in Section 11005, are applicable to the equipment specified in this section.

E. DESIGN REQUIREMENTS:

Evaporative coolers and accessories shall be designed to operate continuously. Each complete unit shall be AMCA certified in conformance with AMCA Standard 210. Certified performance data for all evaporative coolers shall be obtained from tests made in AMCA-approved laboratories.

F. OPERATING REQUIREMENTS:
Outside air will be drawn through the wet evaporative cooler with the air handling unit supply fan. The cooler will be located within the air handling unit downstream of an intake filter and a heating coil and upstream of the supply fan. A pump will circulate water through the cooler.

<table>
<thead>
<tr>
<th>EQUIPMENT NO.</th>
<th>AIRFLOW, CFM</th>
<th>FAN DESIGN STATIC PRESSURE, INCH W.C.</th>
<th>FAN MOTOR POWER, HP</th>
<th>MOTOR VOLTAGE, PHASE, AND FREQUENCY</th>
<th>MEDIA FACE VELOCITY, MAXIMUM, FEET/MIN</th>
<th>MEDIA EVAPORATION EFFICIENCY, MINIMUM, PERCENT</th>
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1.02 QUALITY ASSURANCE

A. REFERENCES:

This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, whether or not the document has been superseded by a version with a later date, discontinued or replaced.

<table>
<thead>
<tr>
<th>REFERENCE</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMCA Standard 210</td>
<td>Laboratory Methods of Testing Fans for Rating</td>
</tr>
<tr>
<td>NFPA 90A</td>
<td>Standard for the Installation of Air Conditioning and Ventilating Systems</td>
</tr>
<tr>
<td>UL 723</td>
<td>UL Standard for Surface Burning Characteristics of Building Materials</td>
</tr>
</tbody>
</table>
B. UNIT RESPONSIBILITY:

The Contractor shall assign unit responsibility as specified in paragraph 11005-3.01 to the equipment specified in this section.

1.03 SUBMITTALS

Submittals shall be provided in accordance with Section 00100 SC-16 and shall include the following information:

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

2. Manufacturer’s information in sufficient detail to determine compliance with this specification.

3. Evaporative cooler performance for the specified operation conditions.

4. Details of the support for the evaporative coolers.

5. Anchor bolt design calculations and details in accordance with paragraph 05501-1.03.

6. Manufacturer’s recommended storage, installation, and start-up procedures.

7. Applicable operation and maintenance information specified in Section 01430.
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8. Seismic design calculations in accordance with paragraph 11005-3.11.

PART 2--PRODUCTS

2.01 MANUFACTURERS

The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement however shall not be construed as an endorsement of a particular manufacturer’s products, nor shall it be construed to mean that named manufacturers’ standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include Premier Industries, and Bessamaire, or approved equal.

2.02 MATERIALS

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>MATERIAL</th>
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<tbody>
<tr>
<td>Housing</td>
<td>Type 316 stainless steel</td>
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<td>Water distribution header</td>
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<td>Spray deflector</td>
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<td>Evaporative medium</td>
<td>Cellulose pad</td>
</tr>
<tr>
<td>Sump</td>
<td>Stainless steel</td>
</tr>
</tbody>
</table>

2.03 CONSTRUCTION

A. HOUSING:

Housing for the entire unit shall be constructed in one piece on a support frame with lifting lugs. Hinged access panels shall allow for access and removal of all internal components from a single side as shown on the drawings. Casing shall be insulated with 1 inch of 1-1/2-pound per cubic foot density neoprene coated NFPA-90 approved acoustical fiberglass insulation.

B. FAN SECTION:
The fan section shall have a top discharge with a flange or other provision to connect sheet metal ductwork as shown on the drawings. The fan shall be centrifugal type with lubricable bearings on each end. Fan motor shall be totally enclosed fan cooled type and shall be sized to be non-overloading on all parts of the fan curve. Fan shall be belt-driven with adjustable sheave on the motor. Manufacturer’s standard vibration isolators shall be provided under the fan and motor, and neoprene flex connectors shall be provided between the fan discharge and the cabinet.

C. WET SECTION:

The wet section of the evaporative cooler shall be welded or mechanically attached to the fan section and shall be supported across its entire width by same support frame. Internal components of the wet section shall include the cooling media, water delivery system, internal plumbing, make-up water valve, overflow and drain fittings.

1. SUMP: The sump shall be leak-proof with welded corners and joints. A media support channel shall extend across the full width of the media and provide for water to flow from the media into the sump. Sump shall be provided with stainless steel couplers for connecting make-up water, overflow, and drain.

2. BYPASS INHIBITOR: An air bypass inhibitor plate shall be provided between the media and the sump to prevent any untreated air flow under the media.

3. WATER DISTRIBUTION SYSTEM: The water distribution system shall include a recirculating pump with mechanical float valve assembly to maintain water level in the sump. An adjustable bleed-off system with metering valve and all required piping and valves shall be provided. The internal plumbing shall include header pipe with drilled orifice holes to spray water upward to a stainless steel splash plate that evenly distributes the water over the cooling media. A PVC union shall be provided in the riser pipe below the header to facilitate removal of the header pipe.

4. COOLING MEDIA: Cooling media shall be rigid, 12-inch deep modules of cellulose evaporation material. Modules shall have at least 123 square feet of evaporative surface area per cubic foot of media. Media shall develop a saturation efficiency of not less than 90 percent and a maximum air pressure drop of 0.315 inches w.c. at 500 feet per minute face velocity.

D. CONTROLS:
Power to the packaged unit shall be through a single feed and a fused disconnect located on the housing, and a starter and separate relay to control water distribution. Hand-Off-Auto switch and pilot lights shall also be mounted on the housing in a NEMA 3R enclosure.

The evaporative cooler shall be controlled by the pump room AHU thermostat. On a high temperature signal from the thermostat, the unit’s automatic fill and drain kit shall fill the sump tank and begin the spraying and evaporation. When pump room temperature drops to the low set point on the thermostat, the unit’s automatic fill and drain kit shall drain the sump tank allowing the evaporative media to dry. The automatic fill and drain kit shall consist of two solenoid valves, fill and drain switch, time clock, and freeze stat.

2.04 PRODUCT DATA

The following product data shall be provided in accordance with Section 00100 SC-33:

1. Spare parts listing in accordance with the manufacturer’s written recommendations.

2. Completed Manufacturer’s Installation Certification Form 11000-A.

3. Completed Manufacturer’s Instruction Certification Form 11000-B.

PART 3--EXECUTION

3.01 INSTALLATION

The evaporative cooler shall be aligned, connected, and installed at the location specified and in accordance with the manufacturer’s written recommendations. The evaporative cooler shall be installed and tested under the direction of factory-trained personnel. The installation and initial operation of all components shall be certified on Form 11000-A as specified in Section 01999.

3.02 FIELD TESTING

After completion of installation, the evaporative cooler shall be completely field tested to demonstrate compliance with the performance requirements as specified.
Testing procedures shall duplicate as nearly as possible the conditions of operation and shall be selected to demonstrate that the equipment is operational and free from damage. Each control device, item or mechanical, electrical, and instrumentation equipment, and control circuit shall be considered in the testing procedures to demonstrate that the equipment has been properly serviced, aligned, connected, calibrated, and adjusted prior to operation.

3.03 TRAINING

During the commissioning period, a factory-trained representative shall train plant personnel in operating and maintenance procedures for the equipment provided under this section for not less than two (2) hours. Training shall conform to Section 01664 and shall be certified on Form 11000-B specified in Section 01999.

END OF SECTION 15726
SECTION 15857
CENTRIFUGAL WALL EXHAUST FANS

PART 1--GENERAL

1.01 DESCRIPTION

A. SCOPE:

This section specifies wall mounted exhaust fans complete with fans, motors, dampers and accessories required for ventilation systems.

B. EQUIPMENT LIST:

<table>
<thead>
<tr>
<th>Item</th>
<th>Equipment No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restroom Exhaust Fan</td>
<td>EF-01</td>
</tr>
<tr>
<td>Generator Exhaust Fan</td>
<td>EF-02</td>
</tr>
</tbody>
</table>

C. OPERATING REQUIREMENTS:

Fan motors shall be nonoverloading on all points of the operating curve. Fans shall be designed for continuous duty service and to comply with the schedule on sheet H1.

D. SOUND AND VIBRATION:

Fans specified in this section shall operate at noise levels below 30 sones, as defined by AMCA Standard 300, and at tip speeds below 8000 fpm.

1.02 QUALITY ASSURANCE

A. REFERENCES:

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

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMCA Standard 210</td>
<td>Laboratory Methods of Testing Fans for Rating</td>
</tr>
<tr>
<td>AMCA Standard 300</td>
<td>Test Code for Sound Rating</td>
</tr>
</tbody>
</table>

B. CERTIFICATION:

Fans shall bear the AMCA rating seal.

1.03 SUBMITTALS

The following information shall be provided in accordance with the requirements of Section 00100 SC-16:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

3. Fan performance curves for the specified operating conditions.

4. Motor data form 11060-A as required in Section 11060.

PART 2--PRODUCTS

2.01 ACCEPTABLE PRODUCTS

Fans shall be weatherproof, horizontal discharge, centrifugal exhaust fans manufactured by Aerovent, Greenheck, Loren Cook, Penn, or equal, modified to provide the specified features and to meet the specified operating conditions.

2.02 MATERIALS

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounting plate</td>
<td>Aluminum</td>
</tr>
<tr>
<td>Fan wheel</td>
<td>Aluminum</td>
</tr>
<tr>
<td>Fan wheel shaft</td>
<td>Steel</td>
</tr>
<tr>
<td>Fan housing</td>
<td>Spun aluminum</td>
</tr>
<tr>
<td>Windband</td>
<td>Aluminum</td>
</tr>
<tr>
<td>Fasteners</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>Damper</td>
<td>Aluminum</td>
</tr>
</tbody>
</table>

Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.03 EQUIPMENT

A. FAN:
Fan housing shall be designed to provide easy access to the motor and fan unit. The fan inlet shall be provided with a venturi throat that is overlapped by the fan wheel.

The fan wheel shall have backward inclined blades as provided standard by the manufacturer for the specified conditions. The wheel shall be statically and dynamically balanced at the factory. The fan wheel shaft, on belt-driven fans, shall be mounted in a heavy duty, permanently sealed, permanently lubricated, ball bearing pillow block. Bearings shall be rated for a minimum AFBMA L-10 bearing life of 100,000 hours.

The entire drive assembly, as a unit, shall be removable without removing the fan assembly from the wall. Belt-driven fans shall be furnished with adjustable pitch sheaves and adjustable motor bases suitable for a plus or minus 5 percent adjustment in operating speed. The V-belt drive shall be as specified in paragraph 11000-2.03.

B. MOTOR:

Unless otherwise specified, the motor shall operate at 1750 rpm and shall be Type 2 as specified in Section 11060. Motors 1 HP and larger shall be the high efficiency type. Motors 1/12 HP and smaller shall be the fan manufacturer's standard motor. Motors shall be mounted on vibration isolators and shall be sealed from the exhaust airstream. Air for the motor shall be introduced by means of an air intake tube, from a location free of discharge contaminants.

Each fan housing shall contain a weatherproof motor shutoff switch and a watertight conduit penetration.

C. DAMPER:

Each fan shall be provided with spring loaded barometric type, aluminum backdraft dampers at the fan inlet.

D. ACCESSORIES:

All fans shall be provided with aluminum or galvanized steel bird screens.

2.04 SPARE PARTS

One set of V-belts shall be provided for each belt-driven fan.
2.05 PRODUCT DATA

The following information shall be provided in accordance with Section 00100 SC-34.

1. Motor data as specified in 16150 and 16151.

2. Certification that the units have been tested and rated in accordance with the applicable AMCA Standard Test Code and Certified Ratings Program.

3. Applicable operation and maintenance data in accordance with Section 01430.

PART 3--EXECUTION

3.01 INSTALLATION

Each fan shall be installed as specified and in accordance with manufacturer's recommendations.

3.02 FIELD TESTING

Each fan shall be completely field tested in accordance with Section 15990 to guarantee compliance with the project manual.
# Part 1 - General

## 1.01 Description

## 1.02 Quality Assurance

## 1.03 Submittals

# Part 2 - Products

## 2.01 General

## 2.02 Materials

## 2.03 Joints and Reinforcing

## 2.04 Duct Sleeves

## 2.05 Hangers and Supports

## 2.06 Access Doors

## 2.07 Flexible Connections

## 2.08 Turning Vanes

## 2.09 Dampers

# Part 3 - Execution

## 3.01 Installation

## 3.02 Tests

## 3.03 Ductwork Schedule
PART 1 - GENERAL

1.01 DESCRIPTION

A. SCOPE:

This section specifies plenums, sheet metal housings, ductwork, equipment connections, reinforcing and other devices required to make the air distribution systems complete and operational.

B. TYPE:

Ductwork and appurtenances shall be designed and fabricated specifically for the applications described under the conditions specified.

C. DESIGN CRITERIA AND CONSIDERATIONS:

1. GENERAL: Unless otherwise specified, sheet metal gage, reinforcing, hanger and support systems, ductwork joint types and other basic design construction details shall be in accordance with the 1985 Sheet Metal and Air Conditioning Contractors National Association (SMACNA) HVAC Duct Construction Standards. Ductwork shall be fabricated to the configurations and dimensions specified. Dimensions specified indicate net free area; dimensions shall be increased by the thickness of the lining where internal lining is required.

2. LOW PRESSURE DUCTWORK: Low pressure ductwork shall convey air with a velocity less than 2000 fpm and maximum static pressure of 2 inches of water column. Low pressure ductwork shall conform to 2-inch w.c. pressure class.

3. MEDIUM PRESSURE DUCTWORK: Not used.

4. SYSTEM LEAKAGE: All joints shall be sealed as required to limit total system leakage to a maximum of 1 percent of the specified equipment airflows.

5. CHANGE IN DUCT SIZE: Change in duct size shall be made by a uniformly tapering section. The change in direction of the tapering section shall not be more than 1 inch in 5 inches of run, unless otherwise specified.
6. BENDS IN DUCT: With the exception of mitered bends, all bends in ducts shall have inside radii equal to the duct width or diameter. Double wall turning vanes shall be provided at all 90-degree mitered bends.

7. DUCT SLEEVES: Whenever ducts extend through concrete or masonry walls, floors or ceilings, they shall be provided with a sleeve as specified in paragraph 15891 2.04. Concrete inserts shall be provided before pour to support all ductwork under this section.

8. DUCT OPENINGS: Access doors or hand holes shall be provided in ducts at locations to reach modulating dampers, fusible links, controllers and any other moveable devices in the ducts. The opening shall be 1 inch less duct size or of adequate size to reach in and maintain these devices. Two-inch diameter nipples with threaded caps shall be welded to the duct where specified or directed by the engineer for balancing the system.

9. VIBRATION ISOLATION FLEXIBLE CONNECTIONS: Flexible connections shall be provided at duct connections to motor driven air handling equipment and other locations specified. Flexible connections shall be UL approved and provided with the necessary angle, straps, bolts, clips, or other fasteners to secure the flexible material to the equipment and ducts. Flexible connections exposed to the weather shall be provided with approved sheet metal weather covers.

10. INSULATION: Insulation shall be as specified in Section 15260.

1.02 QUALITY ASSURANCE

A. REFERENCES:

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

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

<table>
<thead>
<tr>
<th>REFERENCE</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASHRAE CH 1</td>
<td>Handbook   Equipment Volume, Duct Construction</td>
</tr>
<tr>
<td>ASHRAE CH 33</td>
<td>Handbook   Fundamentals Volume, Duct Design</td>
</tr>
<tr>
<td>ASTM A525</td>
<td>General Requirements for Steel Sheet, Zinc Coated (Galvanized) by the Hot Dip Process</td>
</tr>
<tr>
<td>ASTM A527/A527M</td>
<td>Steel Sheet, Zinc Coated (Galvanized) by the Hot Dip Process, Lock Forming Quality</td>
</tr>
<tr>
<td>ASTM B209</td>
<td>Aluminum and Aluminum Alloy Sheet and Plate</td>
</tr>
<tr>
<td>ASTM B211</td>
<td>Aluminum and Aluminum Alloy Bar, Rod, and Wire</td>
</tr>
<tr>
<td>ASTM B308</td>
<td>Aluminum   Alloy 6061 T6 Standard Structural Shapes, Rolled or Extruded</td>
</tr>
<tr>
<td>NFPA 90A</td>
<td>Standard for the Installation of Air Conditioning and Ventilating Systems</td>
</tr>
<tr>
<td>SMACNA</td>
<td>HVAC Duct Construction Standards Metal and Flexible</td>
</tr>
<tr>
<td>UBC</td>
<td>Uniform Building Code</td>
</tr>
<tr>
<td>UMC</td>
<td>Uniform Mechanical Code</td>
</tr>
<tr>
<td>UL 181</td>
<td>Factory made Air Ducts and Connectors</td>
</tr>
<tr>
<td>CEC</td>
<td>California Energy Commission, Building Energy Efficiency Standards</td>
</tr>
</tbody>
</table>

B. REQUIREMENTS OF REGULATORY AGENCIES:

Ductwork construction, installation, and air system performance shall comply with UMC, CEC, ASHRAE, and SMACNA.

1.03 SUBMITTALS
Submittals shall be provided in accordance with Section 00100 SC-16 and shall include the following information:

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

2. An 8-1/2 inch by 11-inch manual with detail sheets or catalog data of flexible duct connectors, duct sleeves, duct access doors, turning vanes, volume dampers, supports, hangers, etc.

**PART 2 - PRODUCTS**

**2.01 GENERAL**

The Contractor shall provide all ductwork, plenums, and all auxiliary work and products of any kind necessary to make the HVAC systems complete and ready for operation. Ductwork shall comply with the following restrictions and conditions:

1. Ductmate systems shall be used as an option by the Contractor for low pressure systems only.

2. Snap lock seams shall not be permitted.

3. Where space conditions permit, full radius turns shall be used at offsets.

4. Turning vanes shall be provided where tees, bends, and elbows are not 1 1/2 times the width at centerline and in all rectangular elbows.
5. Ductwork elbows, takeoffs, and fittings shall be in accordance with the SMACNA and ASHRAE standards for the pressure class and conditions specified.

6. Visible duct deflection, loss of shape, or unwarranted noise or vibration resulting from faulty or inadequate support, reinforcing, metal gage, fabrication, or joint spacing shall be corrected at no expense to the Owner.

2.02 MATERIALS

A. LOW AND MEDIUM PRESSURE SYSTEMS:

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duct</td>
<td>Galvanized steel, ASTM A525 and ASTM A527 or aluminum, alloy 3003 H14, conforming to ASTM B209 and ASTM B211</td>
</tr>
<tr>
<td>Duct sleeve</td>
<td>Galvanized steel, 10 gage or aluminum, alloy 3003 H14, conforming to ASTM B209 and ASTM B211</td>
</tr>
<tr>
<td>Flexible duct connector</td>
<td>Noncombustible, weather and ozone resistant, abrasion-proof woven fiberglass fabric with coating weighing not less than 24 ounces per square yard. Maximum flame spread rating of 25, smoke rating of 50 for all materials including connecting tape, etc. UL 181 approved</td>
</tr>
<tr>
<td>Turning vanes</td>
<td>Galvanized steel or aluminum to match duct material</td>
</tr>
<tr>
<td>Hangers and supports, rivets and bolts, reinforcing</td>
<td>Galvanized steel or aluminum, alloy 6061-T6 conforming to ASTM B308 to match duct material</td>
</tr>
<tr>
<td>Duct lining</td>
<td>Flexible Fiberglass</td>
</tr>
</tbody>
</table>

2.03 JOINTS AND REINFORCING

Transverse stiffeners and joints shall be appropriately spaced to maintain duct cross-section integrity in accordance with the pressure class specified and at the prevailing operating velocities. After joints are crimped, they shall be further secured by bottom punching or riveting. Longitudinal seams shall be Pittsburgh lock and shall be cross broken outward. Intake, or exhaust, side ducts shall be cross broken inward. Discharge ducts shall be cross-broken outward. All plenums and casings shall be similarly cross...
broken and further reinforced with 1 inch x 1 inch x 1/8 inch angles running diagonally between joints, riveted to the casings.

Low pressure ductwork shall have slip joints. Medium pressure ductwork shall have flanged or welded joints. Joints shall not interfere with airflow in the ducts. Exterior ducts shall be stiffened, braced, and supported in a manner designed to maintain duct integrity and cross-section under wind and snow loads specified in the appropriate codes or standards. Interior ducts shall be suitably braced and stiffened at floor and roof penetrations as well as over their unsupported length in a manner designed to maintain duct integrity and limit vibration and noise in accordance with recognized standards of the industry.

Ducts over 17 inches in largest dimension shall be cross broken or beaded on all four sides. In ducts over 72 inches at each transverse joint 3/8-inch stay rods shall be installed. Spacing between rods or rods on side of duct shall not exceed 48 inches.

2.04 DUCT SLEEVES

Sleeve flanges shall not be less than 4 inches wide and shall be installed tight against each side of the barrier. Sleeves shall be 2 inches larger than the duct or external duct insulation. The space between the duct (or insulation) and the sleeve shall be packed with fiberglass or material of original wall. Duct flanges not less than 4 inches wide shall be installed tight against the wall on each side and fastened to the duct sleeves.

2.05 HANGERS AND SUPPORTS

A. GENERAL:

Duct support spacing shall be in accordance with the SMACNA standards for the pressure class and conditions specified and prevailing in the system. Supports shall be spaced to prevent visible duct deflection and loss of system integrity. Aluminum ductwork shall be constructed with strength and dimensional stability comparable to conventional steel duct. In the absence of other criteria, aluminum sheet and reinforcing shall have a moment of inertia three times greater than that recommended for steel ductwork. Supports shall be designed for seismic zone 4.

B. CONCEALED CEILING SPACES:
Rectangular ductwork shall be supported with metal strap hanger screwed to the sides and bottom of duct. One strap each side with minimum of two screws in side and one in bottom of each strap.

C. EXPOSED AREAS:

Rectangular ductwork shall be supported with shelf angle trapeze hanger or unistrut with rods or angles by welding or bolting. Sway bracing shall be provided, minimum of one at right angle to each duct run.

Round ductwork shall be supported with two half round bands with rods bolted to the bands. Sway bracing shall be provided, minimum of one at right angle to each duct run.

2.06 ACCESS DOORS

The doors shall be rigid and shall be provided with airtight gaskets and shall not vibrate or cause noise under service. Doors in insulated ducts shall be the insulated type. Doors shall be continuous hinged type with ventlock latch on outside.

Plenum access doors shall be 24 inches by 66 inches or as specified.

2.07 FLEXIBLE CONNECTIONS

Flexible connection joints shall be airtight and have a minimum allowance of 1-inch slack all around. Flexible connections shall be designed to be removed from the line and be reinstalled without disassembling adjacent ductwork.

Connections shall be installed with a minimum 4-inch clearance between metal parts on fan connections, equipment connections, and our distribution devices.

2.08 TURNING VANES

Turning vanes shall be 2 inch blades for ducts up to 18 inches in either dimension and shall be 4 1/2 inch blades for larger ducts. All turning vane assemblies shall be finished with an air dried phenolic corrosion resistant coating prior to installation. All turning vanes shall be constructed of double thickness vanes.

2.09 DAMPERS
Manually operated, opposed blade or single blade, quadrant type balancing dampers shall be provided in each branch duct take off after leaving the main duct on low pressure systems.

Single-blade dampers shall be constructed for ducts 9-1/2 inches by 30 inches and smaller. Opposed blade dampers shall be constructed with a maximum blade size of 12 inches by 72 inches.

PART 3 - EXECUTION

3.01 INSTALLATION

Ductwork shall be installed in accordance with SMACNA and NFPA. All ductwork indicated on the drawings is schematic. Therefore, changes in duct size, duct configuration, and location may be necessary to conform to field conditions.

Ductwork and accessories shall be installed to provide a system free from buckling, warping, breathing, and vibration. Ductwork installation shall permit installation of other required services without piercing, crimping, or reducing duct sizes. Where space conditions permit, full radius turns shall be used at offsets. The inside of all ducts visible through grilles and registers shall be painted flat black.

All ductwork shall be made airtight. Flanged joints shall be sealed with closed-cell neoprene gaskets compressed between mating flanges. All other joints and seams shall be sealed with liquid or mastic type sealants. Taped joints shall not be permitted. All joints shall comply with the requirements of SMACNA Seal Class A.

All duct fittings shall be fabricated with continuously welded seams and joints.

3.02 TESTS

Tests shall be as specified in Section 00100 SC-14. Duct test holes with patches in ducts shall be provided where directed or necessary for testing and balancing purposes.

3.03 DUCTWORK SCHEDULE

Ductwork material shall be as follows:

All ductwork for this project shall be aluminum as described in paragraph 2.02-A.

END OF SECTION 15891
# SPECIFICATIONS - DETAILED PROVISIONS
Section 15925 – Duct Silencers

## CONTENTS

<table>
<thead>
<tr>
<th>PART 1 - GENERAL</th>
<th>1.01 DESCRIPTION</th>
<th>1.02 QUALITY ASSURANCE</th>
<th>1.03 SUBMITTALS</th>
<th>PART 2--PRODUCTS</th>
<th>2.01 MANUFACTURERS</th>
<th>2.02 MATERIALS</th>
<th>2.03 CONSTRUCTION</th>
<th>PART 3--EXECUTION</th>
<th>3.01 INSTALLATION</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
SECTION 15925
DUCT SILENCERS

PART 1 - GENERAL

1.01 DESCRIPTION

A. SCOPE:

This section specifies dissipative, straight pod sound attenuators to be mounted without duct on stationary wall louvers.

B. EQUIPMENT LIST:

<table>
<thead>
<tr>
<th>EQUIPMENT NO</th>
<th>ITEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLR-1</td>
<td>Pump room duct silencer number 1</td>
</tr>
<tr>
<td>SLR-2</td>
<td>Pump room duct silencer number 2</td>
</tr>
<tr>
<td>SLR-3</td>
<td>Pump room duct silencer number 3</td>
</tr>
</tbody>
</table>

C. OPERATING REQUIREMENTS:

Silencers shall be designed for continuous duty service and to comply with the following:

<table>
<thead>
<tr>
<th>EQUIPMENT NO</th>
<th>WIDTH, INCHES</th>
<th>HEIGHT, INCHES</th>
<th>DEPTH, INCHES</th>
<th>STATIC PRESSURE LOSS AT 300 FPM, INCHES WG</th>
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</thead>
<tbody>
<tr>
<td>SLR-1</td>
<td>36</td>
<td>18</td>
<td>36</td>
<td>.055</td>
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<tr>
<td>SLR-2</td>
<td>36</td>
<td>18</td>
<td>36</td>
<td>.055</td>
</tr>
<tr>
<td>SLR-3</td>
<td>36</td>
<td>18</td>
<td>36</td>
<td>.055</td>
</tr>
</tbody>
</table>

D. ACOUSTICAL PROPERTIES: In addition to the requirements listed above, duct silencers shall provide acoustic performance in accordance with the following:
1.02 QUALITY ASSURANCE

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

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

<table>
<thead>
<tr>
<th>REFERENCE</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM E477</td>
<td>Standard Method of Testing Duct Liner Material</td>
</tr>
<tr>
<td>UL-723</td>
<td>Standard for Safety</td>
</tr>
</tbody>
</table>

1.03 SUBMITTALS

Submittals shall be provided in accordance with Section 00100 SC-16 and shall include the following information:

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

2. Manufacturer’s catalogue data verifying compliance with acoustical and pressure loss requirements specified here.

PART 2--PRODUCTS

2.01 MANUFACTURERS

The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement however shall not be construed as an endorsement of a particular manufacturer’s products, nor shall it be construed to mean that named manufacturers’ standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include Kinetics Noise Control, Ruskin, or equal.

2.02 MATERIALS

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer casing</td>
<td>Galvanized steel</td>
</tr>
<tr>
<td>Internal liner</td>
<td>Galvanized steel</td>
</tr>
<tr>
<td>Baffle fill</td>
<td>Inorganic glass fiber</td>
</tr>
</tbody>
</table>

Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.03 CONSTRUCTION
Duct silencers constructed of multiple smaller modules shall be factory assembled and furnished as complete units. Duct silencers shall be provided with a flange for installation directly to stationary louvers as shown on the drawings.

**PART 3—EXECUTION**

3.01 INSTALLATION

Each silencer shall be installed as specified and in accordance with the manufacturer's recommendations. Adapters required to connect the silencer to the louver shall be the responsibility of the Contractor.
PART 1 - GENERAL

1.01 DESCRIPTION

1.02 QUALITY ASSURANCE

1.03 SUBMITTALS

PART 2—PRODUCTS

2.01 MANUFACTURERS

2.02 GENERAL

2.03 RECTANGULAR SUPPLY AIR REGISTERS

2.04 DAMPERS

2.05 EXTRACTORS

PART 3—EXECUTION

3.01 INSTALLATION
PART 1 - GENERAL

1.01 DESCRIPTION

A. SCOPE:

This section specifies all diffusers, grilles, registers, and extractors associated with the heating, ventilating, and air conditioning systems.

1.02 QUALITY ASSURANCE

All diffusers, grilles, registers, and extractors shall be installed as shown on the drawings and shall be of the size and capacity indicated thereon. Ratings and performance shall be in accordance with AMCA and ADC Standards.

1.03 SUBMITTALS:

Submittals shall be provided in accordance with Section 00100 SC-16 and shall include the following information:

1. A copy of this specification section, with addendum updates included, and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. Catalog data and a complete description of the diffusers, grilles, registers, extractors, and accessories.

3. Specified air quantity, blow length, static pressure design and acoustical performance.

PART 2—PRODUCTS

2.01 MANUFACTURERS

The Owner and Engineer believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement however shall not be construed as an endorsement of a particular manufacturer’s products, nor shall it be construed to mean that named manufacturers’ standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include Titus, Krueger, Anemostat, Metalaire, APD, or equal.

2.02 GENERAL

A factory applied finish shall be provided as scheduled on the drawings. Color for diffusers installed in ceilings shall match ceiling tile color. Each unit shall be set flat against the room surface finish and shall have a felt gasket or seal to prevent air leakage. Diffusers, grilles, and registers shall be as specified on the drawings. All air outlets shall be factory painted and protected prior to shipment. Color shall be as selected by the Construction Manager. All diffusers, grilles, registers, and extractors shall be by a single manufacturer.

2.03 RECTANGULAR SUPPLY AIR REGISTERS

A. TYPE: Aluminum, Double Deflection, ¾” Blade Spacing

1. Material: Aluminum

2. Finish: Satin aluminum

3. Type: Double deflection surface mount

B. MANUFACTURERS:

Titus, Krueger, Anemostat, Metalaire, APD, or equal.
2.04 DAMPERS

Damper shall be all aluminum opposed blade type, unless otherwise noted. Damper shall be mounted on back of grilles. Dampers shall be furnished by the diffuser manufacturer and shall be operated by a key through the grille face.

2.05 EXTRACTORS

Extractors shall be furnished by the diffuser manufacturer and shall be operated by a No. 3 key through the grille face or a No. 2 adaptor for operation from a knob located at the ceiling or on the duct. The extractor unit shall be aluminum, finished with an air-dried phenolic corrosion resistant coating prior to installation.

PART 3--EXECUTION

3.01 INSTALLATION

Diffusers, grilles, registers, and extractors shall be aligned, connected, and installed in accordance with the manufacturer's recommendations and with SMACNA Standards.
SPECIFICATIONS - DETAILED PROVISIONS
Section 15944 – Louvers

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  1.02 QUALITY ASSURANCE ............................................... 2

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  2.02 MATERIALS ............................................................. 3
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  2.04 ACOUSTICAL LOUVERS ............................................ 4
  2.05 PRODUCT DATA ........................................................ 4

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  3.02 TESTING ................................................................. 5
PART 1 - GENERAL

1.01 DESCRIPTION

A. SCOPE:

This section specifies acoustical intake and exhaust air louvers and accessories.

B. EQUIPMENT LIST:

<table>
<thead>
<tr>
<th>EQUIPMENT NO.</th>
<th>AREA SERVICED</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVR-1</td>
<td>Pump Room Louver #1</td>
</tr>
<tr>
<td>LVR-2</td>
<td>Pump Room Louver #2</td>
</tr>
<tr>
<td>LVR-3</td>
<td>Pump Room Louver #3</td>
</tr>
<tr>
<td>LVR-4</td>
<td>Generator Room Intake Louver</td>
</tr>
<tr>
<td>LVR-5</td>
<td>Generator Room Radiator Exhaust Louver</td>
</tr>
</tbody>
</table>

C. PERFORMANCE AND DESIGN REQUIREMENTS:

1. GENERAL: Louver shall be suitable for air supply or discharge service and shall be sized as specified. Louvers over 60 inches in either dimension may be combinations of smaller sections shipped for assembly in the field. All louvers for this project shall be the acoustical type.

<table>
<thead>
<tr>
<th>EQUIPMENT NO.</th>
<th>LOUVER DIMENSION, INCHES</th>
<th>MINIMUM FREE AREA, SQ FT</th>
<th>REMARKS</th>
<th>PRESSURE DROP, IN WG</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVR-1</td>
<td>48 48 8</td>
<td>4.2</td>
<td>Acoustical</td>
<td>.04</td>
</tr>
<tr>
<td>LVR-2</td>
<td>48 48 8</td>
<td>4.2</td>
<td>Acoustical</td>
<td>.04</td>
</tr>
<tr>
<td>LVR-3</td>
<td>48 48 8</td>
<td>4.2</td>
<td>Acoustical</td>
<td>.04</td>
</tr>
<tr>
<td>LVR-4</td>
<td>196 136 8</td>
<td>32.0</td>
<td>Acoustical</td>
<td>.04</td>
</tr>
</tbody>
</table>
2. **ACOUSTICAL LOUVERS**: In addition to the requirements listed above, acoustical louvers shall provide acoustic performance in accordance with the following:

<table>
<thead>
<tr>
<th>OCTAVE BAND CENTER FREQUENCY:</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1,000</th>
<th>2,000</th>
<th>4,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREE FIELD NOISE REDUCTION (DB):</td>
<td>11</td>
<td>11</td>
<td>13</td>
<td>19</td>
<td>21</td>
<td>20</td>
</tr>
</tbody>
</table>

### 1.02 QUALITY ASSURANCE

**A. REFERENCE:**

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

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

<table>
<thead>
<tr>
<th>REFERENCE</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA 45</td>
<td>Designation System for Aluminum Finishes</td>
</tr>
<tr>
<td>AMCA Standard 500</td>
<td>Test Methods for Louvers, Dampers, and Shutters</td>
</tr>
<tr>
<td>ASTM B221</td>
<td>Aluminum and Aluminum Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes</td>
</tr>
<tr>
<td>ASTM C1071</td>
<td>Standard Specification for Thermal and Acoustical Insulation (Mineral Fiber, Duct Lining Material)</td>
</tr>
</tbody>
</table>
B. CERTIFICATION:

Louvers shall bear the AMCA certified ratings seal for both air performance and water penetration.

1.03 SUBMITTALS

Submittals shall be provided in accordance with Section 00100 SC-16 and shall include the following information:

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

PART 2--PRODUCTS

2.01 ACCEPTABLE PRODUCTS

Louvers shall be Airolite, Ruskin, or equal, modified to provide the specified features.

2.02 MATERIALS

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blades</td>
<td>Formed aluminum</td>
</tr>
<tr>
<td>Frame</td>
<td>Formed aluminum</td>
</tr>
<tr>
<td>Fasteners</td>
<td>Stainless steel or aluminum</td>
</tr>
<tr>
<td>Bird screen</td>
<td>Aluminum or galvanized steel</td>
</tr>
</tbody>
</table>
2.03 EQUIPMENT FEATURES

A. BLADES:

Blades shall be of the fixed, drainable type with interlocking blade braces to provide an uninterrupted horizontal line. Blades for all louvers shall be minimum 18 gage thick. Slideable interlocked mullions shall have provisions for expansion and contraction.

B. FRAME:

The frame shall be minimum 16 gage thick for all louvers. The louver frame shall be assembled by welding. The head, sill, and jamb shall be one-piece structural members and shall have an integral calking slot and retaining bead.

C. SCREEN:

The louver shall be furnished with a removable insect screen constructed of 1/4-inch mesh, 16-gage wire and secured within a 10-gage extruded aluminum frame. The screen shall be mounted on the interior louver face but independent of the louver.

D. FINISH:

Unless otherwise specified, all louvers shall receive a 215-R1, Aluminum Association Code AA-C22A41, clear anodized finish after assembly. Minimum coating thickness shall be 0.7 mil.

2.04 ACOUSTICAL LOUVERS

Acoustical louvers shall be as specified in paragraph 15944-2.03 and shall be provided with the additional features specified herein. Acoustical louvers shall be the stationary type with insulated blades. The blades shall be insulated with mineral fiber conforming to ASTM C1071 requirements for acoustical insulation. The mineral fiber shall be held in place by a perforated aluminum sheet which completely covers the insulation and is securely fastened to the underside of the louver blade.

2.05 PRODUCT DATA
Certified results of pressure drop test data and water penetration data for all louvers shall be provided in accordance with Section 00100 SC-14.

PART 3--EXECUTION

3.01 INSTALLATION

The louver shall be aligned, connected, and installed as specified and in accordance with the manufacturer's recommendations. A bituminous coat shall be applied to all aluminum surfaces in contact with concrete or masonry.

3.02 TESTING

After completion of installation, all louvers with operating dampers, both manually and automatically operated, shall be completely field tested to ensure compliance with these specifications.

END OF SECTION 15944
# SPECIFICATIONS - DETAILED PROVISIONS

## Section 16010 - General Electrical Requirements

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</table>

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<td>3.03 INSPECTION</td>
<td>16</td>
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<td>3.04 PREPARATION</td>
<td>17</td>
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<td>3.05 WORKMANSHIP</td>
<td>17</td>
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<td>3.06 PROTECTIVE DEVICE ADJUSTMENTS</td>
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<td>3.07 JOB SITE CONDITIONS AND ELECTRICAL DRAWINGS</td>
<td>17</td>
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<td>19</td>
</tr>
</tbody>
</table>
SECTION 16010
GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 DESCRIPTION

Contractor shall provide all the materials and equipment, and perform all work necessary for the complete execution of the electrical work as indicated on the Drawings, as specified herein, and as specified in other Specification Sections. Miscellaneous appurtenances are not necessarily specified or indicated on the Drawings. Contractor shall provide all labor and materials not specifically indicated on the Drawings or specified in these Specifications, yet required to ensure proper and complete operation of all systems.

This Section summarizes the general requirements for electrical work, and forms a part of all other Sections of these Specifications, unless otherwise specified.

1.02 QUALITY ASSURANCE

A. General

1. It is the intent of these Specifications and the Drawings, to secure highest quality in all equipment and materials, and to require first-class workmanship, in order to facilitate trouble free operation and minimum maintenance of the electrical system.

2. All work, including installation, connection, calibration, testing and adjustment, shall be performed by qualified, experienced personnel who are technically skilled in their trades, are thoroughly instructed, and are competently supervised by a certified electrician in the state of California. The resulting complete installation shall reflect professional quality work, employing industrial standards and methods. Any and all defective material or inferior workmanship shall be corrected immediately to the satisfaction of the District and at no additional cost to the District.

3. All equipment and materials shall be new, listed by UL and bearing the UL label, unless exception to this requirement is inherent to an individual item specified herein, or exception is otherwise specified, or approved by the District.
4. Equipment and materials shall be the products of reputable, experienced manufacturers. Singular items in the project shall be the products of the same manufacturer. All equipment and materials shall be of industrial grade and heavy duty construction, shall be of sturdy design and manufacture, and shall be capable of long, reliable, trouble-free service.

5. Contractor shall furnish manufacturer’s electrical equipment of the types and sizes specified which has successfully operated for not less than the past two years, except where specific types are named by manufacturer and catalog number or designation under other Sections of the Contract Documents.

B. Environmental Sustainability

1. All electrical equipment and their enclosures shall be suitable for operation in the ambient conditions and area classification designations associated with the locations designated in the Contract Documents.

2. All electrical equipment shall be capable of operating successfully at full-rated load, without failure, when the ambient temperature of the air is 50°C. Unless specified otherwise or indicated otherwise on the Drawings, heating and cooling devices shall be provided in order to maintain all electrical equipment and instrumentation devices to within a range equal to 20 percent above the minimum and 20 percent below the maximum of the rated environmental operating ranges. All power wiring and temperature controls for these devices shall be provided by the Contactor.

C. Factory Tests

Factory tests are required for all electrical equipment and assemblies applicable to the specific project. Perform factory tests in accordance with the requirements of the particular equipment specification sections and in accordance with the codes and standards specified as applicable to the equipment. Items to be factory tested shall include, but not be limited to:

1. Motor Control Centers

2. Electrical Service Switchboards and Distribution Switchboards

3. Variable Frequency Drives

4. Solid State Starters

5. Automatic Transfer Switches
6. Manual Transfer Switches
7. Induction Motors
8. Emergency Generators
9. Custom Control Panels
10. Programmable Logic Controllers
11. Instrumentation and Controls

D. Codes and Standards

Provide electrical equipment and materials, including installation, conforming to the following codes and standards, as applicable. The equipment and materials shall bear labels to indicate manufacturing conformance to the specified standards, or equal.

1. American National Standards Institute (ANSI)
2. California Energy Commission (CEC), Title 24
3. Institute of Electrical and Electronic Engineers (IEEE)
4. National Electrical Manufacturers Association (NEMA)
5. Underwriters' Laboratories (UL)
7. Factory Mutual (FM)
8. Insulated Power Cable Engineers Association (IPCEA)
10. NFPA 70 - National Electrical Code (NEC)
12. Occupational Safety and Health Regulations of Occupational Safety and Health Administration (OSHA)
13. City and State Electrical Codes. Applicable portions of local and state codes.

14. Serving Utility Company (service, metering and interconnection requirements)

15. South Coast Air Quality Management District (SCAQMD)

16. National Institute of Standards and Technology (NIST)

17. National Electric Testing Association (NETA)


19. Certified Ballast Manufacturers Standards

20. Illuminating Engineering Society Handbook Standards

21. Basic Electrical Regulations, Title 24, State Building Standards, California Administrative Code

22. Low Voltage Electrical Safety Orders, Title 8, Division of Industrial Safety, State of California

Underwriters' Laboratories Approval: All equipment furnished by the Contractor shall be listed by and shall bear the label of Underwriters' Laboratories, Incorporated (UL), or Edison Testing Labs (ETL), or of a Nationally Recognized Testing Laboratory (NRTL) acceptable to the District.

Where the Drawings or these Specifications call for equipment and workmanship to be of better quality of higher standard than required by the above codes, standards, rules, and regulation, then said Drawings and Specifications shall prevail. Nothing on the Drawings or in these Specifications shall be construed to permit work in violation of the above codes, standards, rules, and regulations and the Contractor shall be held responsible for any work which is not acceptable.

In case of conflict or disagreement between building codes, state law, local ordinances, industry standards, utility company regulations, Drawings and Specifications, or within the Contract Document itself, the most stringent condition shall govern. The Contractor shall promptly notify the District in writing of such differences.
1.03 UTILITY COMPANY REQUIREMENTS

A. Unless specified otherwise, the District will make application for electric and telephone service (if applicable). The District will pay utility company connection fees for permanent service. Fees for temporary service during construction shall be paid by the Contractor.

B. All work for electrical power shall be performed in accordance with the requirements of the respective serving utility companies.

C. Immediately after the award of the contract, the Contractor shall notify the serving utilities that the project is under construction and provide them with all pertinent information, including the dates on which the services will be required.

D. Shop drawings shall be submitted to the power utility company with the appropriate panel dimensions (top view and elevation view) and EUSERC (Electric Utilities Service Equipment Requirement Committee) No. for service entrance and metering sections (electrical service switchboard), unless indicated otherwise on the Drawings. The power utility company serving the District is Southern California Edison (SCE).

E. Contractor shall coordinate details and timing of service switchboard installation with SCE, provide all required temporary service, and include all utility connection fees for temporary service in his bid proposal. In addition, all coordination and fees associated with obtaining from SCE the maximum available short circuit current at the secondary side of the service transformer shall be obtained by the Contractor.

The District will “Green Tag” the service when all SCE requirements and NEC grounding requirements are met. Contractor shall provide the services of an independent testing consultant for all testing required to Green Tag the service, as specified herein and in Section 16040.

F. Where indicated on the Drawings, the Contractor shall construct new electrical services per SCE requirements, the SCE Service Plan, and in accordance with the Contract Documents. Contractor shall furnish and install all facilities as required by the SCE Service Plan and as indicated on the Drawings. Facilities may include conduits, intercept box, transformer pad, slab box, service switchboard, and associated appurtenances. SCE will furnish and install the service transformer and conductors from utility power location to transformer, and from transformer to service meter. Copies of the SCE Service Plan (if available) are attached in Special Conditions or in an Appendix to these Specifications.

G. Contractor shall install telephone service entrance conduit, backboard, receptacles, grounding, and other telephone equipment indicated on the Drawings in accordance with the serving utility's requirements.
1.04 SUBMITTALS

A. General

Contractor shall provide submittals (shop drawings) in accordance with the requirements of the District’s General Conditions, and as specified herein and in other Sections of Division 16. Shop drawings shall be submitted for the following items:

1. All electrical equipment and materials including conduit, conductors, pull boxes, junction boxes, and appurtenances.

2. Switchboards, panelboards, motor control centers, variable frequency drives, terminal cabinets, transformers, and other major equipment or apparatus.

3. Control panels and other specially-fabricated or custom-made equipment.

4. Other items as may be specifically called for herein or per other Sections of the Specifications.

B. Shop Drawings

1. Submit a complete list of all materials, equipment, apparatus, and fixtures; including manufacturer’s product literature and data; clearly indicating which equipment, materials, accessories, etc. the Contractor proposes to use. The list shall include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

2. Contractor shall submit detailed dimensioned shop drawings of all designated equipment for District’s review before fabrication. Drawings submitted for review shall include front views, top and bottom views, internal elevation views, sections, and anchoring details. Separate drawings shall be submitted for control and wiring diagrams. Wiring diagrams shall be provided for all electrical equipment furnished, except lighting. Shop drawings shall be checked by the Contractor before submittal for review by the District, and the Contractor shall certify that the submittals are in accordance with the Drawings and Specifications. Should an error be found in a shop drawing during installation of equipment, the correction, including any field changes found necessary, shall be noted on the drawings, and the as-built drawings shall be provided with the final equipment operation and maintenance manuals.
3. Manufacturer catalog literature, bulletins, brochures or the like shall be submitted for all materials and equipment. This data shall be submitted together with a clear indication (arrows) of the specific item or items, or class of items proposed, in order to establish written record of the Contractor's intent. A list of items indicating "as specified" will not suffice. A manufacturer's name alone will not suffice. Each sheet of descriptive literature submitted shall be clearly marked by the Contractor to identify the material or equipment as follows:

a. Lamp fixture descriptive sheets shall show the fixture schedule type for which the sheet applies.

b. Equipment and materials descriptive literature and drawings shall indicate the Specification Section and Subsection for which the equipment and/or materials applies.

c. Sheets or drawings showing more than the particular item under consideration shall have crossed out all but the pertinent description of the item for which review is requested.

d. Equipment and materials descriptive literature not readily cross-referenced with the Drawings or Specifications shall be identified by a suitable notation.

e. Schematic, wiring, and connection diagrams for all electrical equipment shall be submitted for review. A manufacturer's standard connection diagram or schematic showing more than one scheme of connection will not be accepted, unless it is clearly marked to show the intended connections. Connection diagrams shall indicate field installed equipment with the specified drawing device number or name as illustrated on the Construction Drawings and submitted shop drawings.

4. Submit data for earthquake (seismic) design and restraint with the shop drawing submittals for all switchboards, panelboards, motor control centers, variable frequency drives, and control panels. Anchorage data and details shall be provided for same. Calculations and details shall be stamped by a California registered "Civil" or "Structural Engineer." Refer to Special Conditions and Section 11005 for special seismic design requirements.
C. As-Built Drawings

Contractor shall prepare, maintain, and submit as-built Drawings in accordance with the District’s General Conditions, and as specified herein.

At the completion of the Work, Contractor shall furnish the District with three (3) final sets of as-built electrical Drawings marked with any changes, deviations or additions to any part of the electrical work. During construction, one (1) red-lined set of as-built Drawings shall be maintained at the job site by the Contractor until the final as-built Drawings are received by the District.

Contractor shall clearly indicate on the as-built Drawings the following information:

1. All conduit runs as actually installed.

2. Location of all underground conduits and stub-outs accurately dimensioned.

3. Forming, cabling, and identification of all power and control conduit and wiring within manholes, pull boxes, junction boxes, and terminal boxes.

4. Interior views of each manhole and pull box identifying each conduit entrance by conduit number.

5. All changes, deviations, or additions to any part of the electrical work, including, but not limited to: locations, routing, dimensions, wiring, or connections.

D. Operation and Maintenance Manuals

Contractor shall provide operation and maintenance (O&M) manuals for all electrical equipment in accordance with District’s General Conditions, Section 01430, and as specified herein.

The manuals shall include all system drawings, block diagrams, single line and control diagrams, wiring schematics, loop diagrams, shop drawings, manufacturer product literature and data for supplied equipment and other pertinent data required to completely describe the operation and maintenance of the installed electrical system.

These manuals shall be submitted prior to final acceptance of the system and shall reflect all as-built conditions.
As a minimum, the electrical system information in the O&M manuals shall contain:

1. System operating instructions written for the benefit of the District's operating personnel for normal operational condition and utilizing names of controls as they appear on nameplates.

2. Installation instructions.

3. Pre-energizing, energizing, and de-energizing procedures.


5. Troubleshooting instructions.


7. Instructions for ordering replacement parts.

8. Part List
   a. List of fuses, lamps, and other expendable equipment and devices with manufacturer names and part numbers.
   b. List of all vendors, addresses, and phone numbers.

E. Miscellaneous Reports

Contractor shall submit all other reports as called for in these Specifications at the times specified. These miscellaneous reports include, but are not limited to, test procedures, records of electrical test results, and manufacturer certificates of inspection.

F. Manufacturer's Certified Reports

Each equipment manufacturer, or his authorized representative, shall submit a written report with respect to his equipment certifying the following:

1. Pre-Startup Complete
   a. The equipment has been properly installed, wired, and connected in accordance with the manufacturer's requirements.
   b. The equipment is in accurate alignment.
c. Manufacturer has checked, inspected, and adjusted the equipment as necessary.

2. Startup and Field Testing Complete

a. Manufacturer was present when the equipment was placed into operation.

b. The equipment has been operated under full load conditions and operated satisfactorily.

c. All field testing, including operational demonstration and system validation testing, has been completed and equipment performed satisfactorily throughout each test.

d. The equipment is fully covered under the terms of the guarantee.


In accordance with Section 16040, Contractor shall submit electrical short-circuit/coordination study, arc-flash hazard study, and testing report certifying proper setting of all protection devices, ground testing, and arc-flash hazard labeling.

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Delivery

Contractor shall require that all electrical materials and equipment be shipped and delivered in accordance with the manufacturer’s requirements. Deliver electrical materials and equipment in manufacturer's original cartons or containers with seals intact, as applicable. Unless specified otherwise, deliver conductors in sealed cartons or on sealed reels, ends of reeled conductors factory sealed. Deliver large multicomponent assemblies in sections that facilitate field handling and installation.

B. Handling

Contractor shall unload and handle materials and equipment in accordance with manufacturer's recommendations. Lift large or heavy items only at the points designated by the manufacturer. Use padded slings and hooks for lifting as necessary to prevent damage.
C. **Storage**

Store electrical equipment and material in accordance with the manufacturer’s requirements. Where enclosures are specified to be provided with space heaters, Contractor shall furnish temporary power to equipment space heaters to prevent condensation until the equipment is installed and energized.

Unless designed for outdoor exposure, store electrical materials off the ground and under cover to prevent corrosion, contamination, or deterioration.

1.06 **COORDINATION OF WORK AND TRADES**

A. Electrical work shall conform to the construction schedule and progress of other trades. The electrical construction shall be performed in cooperation with all other trades so that a neat and orderly arrangement of the work as a whole shall be obtained.

B. Electrical components on all equipment shall be handled, set in place, connected, checked out, serviced, and placed in readiness for proper operation to the satisfaction of the District all within the scope of work intended under this Section.

C. Before any work is commenced, Contractor shall verify with the equipment manufacturers that equipment dimensions and arrangements will allow for equipment installation in the spaces provided for on the Drawings, including, but not limited to: all switchboards motor control centers, variable frequency drives, panelboards, control panels, terminal cabinets, transformers, and other items of electrical equipment or apparatus; and that the installation spaces indicated will provide for all required ventilation, clearances, access, and work space.

D. Before installing any equipment, conduit, or materials, the Contractor shall examine the complete set of Contract Documents (Drawings and Specifications) and approved shop drawings, and confirm all dimensions and space requirements.
1.07 COORDINATION OF THE ELECTRICAL SYSTEM

A. Contractor shall verify all actual equipment and motor full-load and locked rotor current ratings. The necessary minimum equipment, conductors, and conduit sizes are indicated on the Drawings. If the Contractor furnishes equipment of different ratings, the Contractor shall coordinate the actual current rating of equipment furnished with the branch circuit conductor size, the controller size, the motor starter, and the branch circuit over current protection. The branch circuit conductors shall have a carrying capacity of not less than 125% of the actual full-load current rating. The size of the branch circuit conductors shall be such that the voltage drop from the overcurrent protection devices up to the equipment shall not be greater than 2% when the equipment is running at full load and rated voltage. Conductor ampacities shall be derated in accordance with NEC, Table 310-16 for ambient temperatures of 114-122°F.

B. Unless specified otherwise, the motor running solid state overcurrent protection devices shall be ambient temperature compensated for 50°C and be rated or selected to trip at no more than 125% of the motor full-load current rating for motors marked to have a Class B temperature rise not over 80°C or motors marked with a service factor not less than 1.15, and at no more than 115% for all other types of motors.

C. Unless specified otherwise, the motor branch circuit overcurrent protection device shall trip open in 10 seconds or less on locked-rotor current of the motor. This device shall also protect the motor branch circuit conductors and the motor control apparatus against overcurrent due to short circuits or ground faults. The motor control circuits shall have overcurrent protection of the type specified in the Specifications, or indicated on the Drawings.

1.08 RELATED WORK SPECIFIED ELSEWHERE

A. The Contract Documents are a single integrated document, and as such all Specification Divisions and Sections apply. It is the responsibility of the Contractor and its Subcontractors to review all sections to ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Sections of the Specifications specifying equipment and/or systems requiring electrical power and/or control.

2. Division 16 – Electrical

3. Division 17 – Instrumentation and Controls
1.09 PERMITS

Contractor shall obtain and pay for all permits, licenses, and inspections required for electrical construction work by public agencies and utility companies having jurisdiction, except as otherwise specified.

1.10 OUTAGES

A. Contractor shall keep equipment system power outage periods to the minimum time feasible, and only for such times and durations as may be approved by the District. Contractor shall submit any request for an equipment system power outage (shutdown) in writing to District for approval at least 10 working days in advance of said shutdown. The written request shall include the date, time, location, affected equipment and systems, and proposed duration of the shutdown. Contractor shall bear all overtime costs for outages required to be performed during non-working hours.

B. Contractor shall keep facility power outage periods to the minimum time feasible, and only for such times and durations as may be approved by the District and SCE. Contractor shall submit request for a facility power outage (shutdown) in writing to District for approval at least 45 working days in advance of said shutdown. The written request shall include the date, time, location, and proposed duration of the shutdown. If the proposed facility shutdown is approved by the District, Contractor shall provide all necessary coordination with SCE and the District throughout the planning and shutdown period. Contractor shall bear all overtime costs for facility outage required to be performed during non-working hours.

1.11 AREA CLASSIFICATION DESIGNATIONS

A. General

For purposes of defining electrical enclosure and electrical installation requirements, certain areas have been classified in this Section, other Specification Sections, or indicated on the Drawings. Electrical equipment, materials, and installations within these areas shall conform to the equipment standards and code requirements for the areas involved.

B. Indoor Locations

Unless specified otherwise, electrical work installed in indoor, dry, non-corrosive areas that are not subject to wash down and not specifically classified shall be general purpose locations. Enclosures for instruments, control panels, controllers, terminal cabinets, junction boxes, devices, etc., in general purpose locations shall be rated NEMA 12. Enclosures for motor control centers, switchboards, panelboards, and variable frequency drives in general purpose locations shall be rated NEMA 1A (gasketed).
C. **Outdoor Locations**

Unless specified otherwise, electrical work installed in indoor areas subject to wash down or installed in outdoor areas shall be classified as wet locations. Enclosures for instruments, control panels, controllers, terminal cabinets, junction boxes, devices, etc., in wet locations shall be rated NEMA 4X. Enclosures for motor control centers, switchboards, panelboards, and variable frequency drives in wet locations shall be rated NEMA 3R (weatherproof). Wherever possible, outdoor enclosures shall be gasketed, and shall be provided with hinged and padlockable doors.

D. **Corrosive Locations**

Unless specified otherwise, electrical work installed in indoor or outdoor areas with exposure or potential exposure to chemical liquids, chemical gases, sewage, or sludge shall be classified as corrosive locations. Enclosures for instruments, control panels, controllers, terminal cabinets, junction boxes, devices, etc., in corrosive locations shall be rated NEMA 4X. Wherever possible, NEMA 4X enclosures shall be constructed of Type 316 stainless steel, and shall be provided with hinged and padlockable doors.

E. **Hazardous Locations**

Unless specified otherwise, electrical work installed in indoor or outdoor areas with exposure or potential exposure to flammable gases or vapors, or combustible dusts shall be classified as hazardous locations. Enclosures for instruments, control panels, controllers, terminal cabinets, junction boxes, devices, etc., in hazardous (classified) locations shall be provided in accordance with NEC Articles 500 through 504.

### 1.12 WARNING SIGNS

A. Unless specified otherwise, permanent warning and caution signs shall be mounted at the site and on all mechanical equipment which may be started automatically or from remote locations for personnel safety. Signs shall be fabricated in accordance with Porcelain Enamel Institute Specification S-103 and shall be suitable for exterior use. Mounting details shall be in accordance with the manufacturer's recommendations. Signs shall be located as approved by District. Provide a minimum of one (1) sign at each equipment location.

B. Warning signs shall be 7 inches high by 10 inches wide, colored yellow and black, on not less than 18 gauge vitreous enameling stock. Sign shall read:

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CAUTION
THIS EQUIPMENT STARTS
AUTOMATICALLY
BY REMOTE CONTROL
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C. Where specified, provide a minimum of one (1) sign mounted on the entrance door of generator, blower, or compressor rooms. Sign shall read:

CAUTION
HEARING PROTECTION
SHALL BE WORN IN THE AREA

D. Permanent and conspicuous warning signs shall be mounted on all equipment and doorways to equipment rooms where the voltage exceeds 600 volts.

E. Where specified, provide a minimum of one (1) sign mounted on the door of pump or electrical rooms. Warning signs shall be 7 inches high by 10 inches wide, colored red and white, on not less than 18 gauge vitreous enameling stock. Sign shall read:

WARNING
HIGH VOLTAGE
AUTHORIZED PERSONNEL ONLY

1.13 GUARANTEE AND WARRANTY

Contractor shall guarantee all work of Division 16 in accordance with the General Conditions. With respect to equipment, guarantee shall cover (1) faulty or inadequate design; (2) improper assembly or erection; (3) defective workmanship or materials; and (4) incorrect or inadequate operation, or other failure. For equipment bearing a manufacturer's warranty in excess of one (1) year, furnish a copy of the warranty to the District, who shall be named as beneficiary.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

Contractor shall provide new materials and equipment as required to complete all indicated and specified electrical work, including incidental items inferable from the Contract Documents that are necessary to complete the work. Provide materials and equipment of latest design, standard products of established manufacturers. Custom products shall be provided where required to comply with specified performance requirements or special features and capabilities.

For uniformity, only one manufacturer is acceptable for each type of product. Manufacture individual parts to standard sizes and gages so repair parts can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not be placed in service at any time prior to delivery, except as required for factory or shop tests.
A. **Prohibited Materials**

Aluminum conductors are not acceptable.

B. **Damaged Products**

Notify the District in writing if any equipment or material is damaged. Do not repair damaged products without prior written approval.

C. **Factory Finishes**

Unless specified otherwise in other Division 16 Sections or in the Special Conditions, the sheet metal surfaces of equipment enclosures shall be phosphatized and coated with a rust resisting primer. Over the primer, apply a corrosion resistant baked enamel finish on the interior and exterior metal surfaces. The exterior color shall be ANSI No. 49 medium light gray. The interior color shall be white. Hardware shall have a corrosion resistant finish. Sheet metal enclosures and lighting fixtures, in corrosive areas, shall have an outer coating of corrosion resistant epoxy.

**PART 3 - EXECUTION**

**3.01 GENERAL**

Contractor shall install electrical work in accordance with the codes and standards specified, except where more stringent requirements are indicated or specified. Prior to commencing construction, Contractor shall verify that equipment and materials properly fit the installation space with clearances conforming to the codes and standards specified, except where greater clearance is indicated. Contractor shall perform work as required to correct improper installations, at no additional cost to the District.

**3.02 ELECTRICAL SUPERVISION**

In addition to supervision required under the General Conditions, Contractor shall assign a competent representative to supervise the electrical construction work from beginning to completion and final acceptance.

**3.03 INSPECTION**

Contractor shall inspect each item of equipment and material for damage, defects, completeness, and correct operation before installing. In addition, Contractor shall inspect previously installed related work and verify that it is ready for installation of electrical work.
3.04 PREPARATION

Prior to installing electrical work, Contractor shall ensure that installation areas are free of debris and clean. Contractor shall maintain the areas in a broom-clean condition during installation operations. Contractor shall clean, condition, and service equipment in accordance with the manufacturer's instructions, approved submittals, and other requirements indicated or specified.

3.05 WORKMANSHIP

Contractor shall employ skilled craftsmen experienced in installation of the types of electrical equipment and materials specified. Contractor shall use specialized installation tools and equipment as applicable. Contractor shall construct acceptable installations free of defects. Refer to Part 1.02 herein.

3.06 PROTECTIVE DEVICE ADJUSTMENTS

Contractor shall adjust all protective devices in accordance with tabulated settings listed in the approved coordination study per Section 16040. In addition, adjustments shall conform to SCE requirements and IEEE Standard 242. No equipment shall be operated prior to said adjustments being properly completed and field verified/tested.

3.07 JOB SITE CONDITIONS AND ELECTRICAL DRAWINGS

A. Job Site Conditions and Drawings

1. The Drawings indicate diagrammatically the desired location and arrangement of outlets, conduit runs, equipment, and other items. Exact locations shall be determined in the field based on the physical size and arrangement of equipment, finished elevations, and obstructions. Locations indicated on the Drawings, however, shall be adhered to as closely as possible.

2. All equipment and conduit shall be installed in such a manner as to avoid all obstructions, preserving headroom, and keeping openings and passageways clear. Lighting fixtures, switches, convenience outlets, and similar items shall be located within finished rooms as indicated on the Drawings. Where these Drawings do not indicate exact locations, Contractor shall propose locations to the District for final approval by District prior to installation. Where equipment is installed without approval and must be moved (as determined by the District), it shall be moved without additional cost to the District.
3. Allowance has been made in the design for the number of conduits, conductors and cables, which the District considers adequate for feeding various equipment and drives. These circuits and diagrams are based on available data pertaining to a particular design of equipment and portray the systems which the District has chosen to effect the required operation and level of control. Equipment provided by the Contractor (even though of the make and model specified) may differ in detail, arrangement, connections or form from that indicated on the Drawings. If the Contractor uses equipment which differs from the equipment shown in major aspects and requires modifications to power, control or other electrical systems (including, but not limited to, size and quantity changes to conductors, conduits, starters, circuit breakers, control devices, etc.), the District's acceptance of the equipment will be based upon the Contractor providing the modification required, and they shall be of the same quality as shown and shall be provided at no additional costs to the District.

4. The Drawings do not, and are not intended to, show all required equipment, such as pull boxes, junction boxes, etc. nor to indicate all mechanical or structural difficulties that may be encountered which would necessitate routing alteration, or fittings. Items not specifically mentioned in these Specifications or noted on the Drawings or approved shop drawings, but which are obviously necessary to make a complete working installation, shall be deemed to be included herein.

5. Discrepancies shown on different Drawings, between Drawings and actual field conditions, or between Drawings and Specifications shall be promptly brought to the attention of the District for direction.

6. The equipment alignment and conduit shall be varied due to architectural changes, or to avoid work of other trades, without extra expense to the District.

B. Protection of Existing and New Facilities

1. Contractor shall hand dig or otherwise cautiously dig the trenches for the underground lines in areas where interferences are possible or where electric lines must pass or cross below or above existing facilities.
2. Contractor shall protect electrical equipment and materials until final acceptance by the District. Contractor shall protect factory painted surfaces from impact, abrasion, discoloration, and other damage. Contractor shall keep electrical equipment, materials, and insulation dry at all times. Contractor shall maintain heaters in equipment connected and operating until equipment is placed in operation. If partial dismantling of equipment is required for installation, box or wrap the removed parts until reinstalled. Contractor shall repair or replace damaged work as directed by the District, and at no additional cost to the District.

3.08 FIELD TESTING AND QUALITY CONTROL

A. General

1. Prior to testing equipment including wiring and cables, the equipment shall be installed and anchored in accordance with the manufacturer's recommendations and the Contract Documents. A minimum of ten (10) working days in advance of testing, Contractor shall provide written notice to the District for installation inspection. District's and equipment manufacturer's acceptance of installation shall be obtained prior to the commencement of any testing.

   a. The District intends to observe all testing, thus, the Contractor shall prepare a testing schedule showing daily work and projecting same for a minimum of three (3) weeks. Contractor shall maintain a current testing schedule and submit updated schedules to the District on weekly intervals.

   b. Contractor shall provide a minimum of ten (10) working days advance notice to the District for the scheduling of any testing.

   c. Contractor shall provide the manufacturers' documentation for testing for all equipment.

   d. In the event a retest is required due to equipment failure, adverse testing conditions, or installation deficiency, Contractor shall schedule the retest. Any impact to project schedule or testing schedule shall be borne by the Contractor.

2. Inspection and test records shall be submitted to the District no later than thirty (30) days after completion of the individual test and prior to energizing of equipment.

3. All tests shall be performed with the equipment or material de-energized, except where otherwise specifically required by the nature of the test.
4. All items not in conformance with the requirements of these Specifications shall be corrected by the Contractor.

5. Upon completion of various phases of the project, electrical equipment and wiring and cabling systems shall be inspected and tested in accordance with this Specification. All testing shall be in accordance with the applicable ANSI, IEEE, NETA, NEMA, or other national standard, and in accordance with the specific manufacturer's instruction bulletins or other literature supplied with the equipment to be tested, and the test equipment manufacturer's operating instructions. All tests that are required to be performed, whether performed by the Contractor or by the Testing Consultant (refer to Part 3.08E herein) shall be in accordance with NETA Standard for Acceptance Testing Specifications.

6. No equipment shall be energized until the testing and setting of protective devices per Section 16040 and testing as specified herein has been completed and accepted by the District.

7. Contractor shall provide all test data in tabulated form as approved by the District. Insulation testing (high potential testing) and continuity testing data shall include conductor number, size, test value, and expected value for each conductor.

8. Contractor shall check all equipment for proper mechanical adjustment and freedom of operation. All electrical equipment, both pre-wired and field-wired shall be field-tested for functional operation, including all intended modes and sequences of operation. This shall include switches, relays, non-adjustable circuit breakers, contractors, etc., including control interlock and sequence circuits. All necessary adjustments shall be made on apparatus in accordance with the manufacturer's instructions and design requirements. Alarm systems and circuits shall be tested by manually operating initiating devices. Relays and control components that may prove to be functioning incorrectly or otherwise appear to be unreliable shall be repaired or replaced as necessary. An electrical system will not be accepted until it is tested in its entirety and the results reported to and accepted by the District.
9. Each equipment manufacturer shall furnish the services of an authorized representative especially trained and experienced in the installation of his equipment to: (1) supervise the equipment installation in accordance with the Contract Documents, approved submittals, and manufacturer's instructions; (2) inspect, check, adjust as necessary, and approve the installation prior to start up; (3) submit certification that equipment is ready to start-up and test; (4) be present when the equipment is placed into operation and tested; (5) repeat the inspection, checking, adjusting, and testing until all trouble or defects are corrected and the equipment installation and operation are acceptable; and (6) prepare and submit the specified Manufacturer's Certified Report (refer to Part 1.04F herein). Contactor shall include all costs for manufacturer representatives' services in the Contract Price.

10. All costs associated with equipment and material testing and retesting (if required) shall be paid by the Contractor.

B. Testing Power, Control, and Lighting Circuits - 600 V and Below

Contractor shall perform continuity checks of all power, control and lighting conductors and cables, including each conductor of multi-conductor and multi-pair cables. Continuity checks shall be performed prior to termination of conductors and cables, and any testing by the Testing Consultant.

1. Contractor shall visually check all conductor and cable connections, verify conductor numbers, and verify that the actual wiring conforms to the Drawings and shop drawings.

2. Each power conductor shall be tested to ensure proper phase identification.

3. The conductor ends shall be cleaned and guarded for personnel safety during testing. Circuits in the immediate vicinity that are not under test shall be grounded.

4. Contractor shall perform insulation resistance tests on all 600 V rated power conductors. Each conductor shall be tested against ground with the conduit and/or all other conductors connected to ground. Motor feeder circuits shall be tested with motors disconnected and the controller open. Lighting panelboard main feeder circuits, including lighting panelboard and transformer, shall be tested with the branch circuit breakers open. Testing shall be for one minute using 1000 V DC. Values of insulation resistance less than 50 megohms shall not be acceptable.

5. Control and lighting circuits require only functional tests.
6. Branch lighting circuits containing light fixtures and receptacles require only functional tests.

7. Contractor shall check all AC and DC control circuits for short circuits and extraneous grounds.

8. Contractor shall perform functional tests of all power, control, and lighting circuits. Alarm conditions shall be simulated for each alarm and control point, and alarm indicators shall be checked for proper operation. All control circuits shall function as intended by the Contract Documents. Metering and indication lights for motors shall be checked for proper operation. All lighting panels, circuits, lighting fixtures, and receptacles shall be tested for proper operation.

9. The District shall be notified if minimum insulation resistance values are not obtained and if any functional tests fail.

C. **Testing Instrumentation, Signal, and Alarm Circuits - 300 V and Below**

1. Contractor shall perform continuity checks of all instrumentation, control, signal, and alarm conductors and cables, including each conductor of multi-conductor and multi-pair cables. Continuity checks shall be performed prior to termination of conductors and cables.

2. Contractor shall visually check all conductor and cable connections, verify conductor numbers, and verify actual wiring conforms to the Drawings.

3. Performing insulation resistance tests on conductors and cables will not be required, but functional tests shall be performed.

4. All signal and alarm conditions shall be simulated for each status, alarm and control point, and status/alarm indicators checked for proper operation, similar to that required for control circuits.

5. Contractor shall check all AC and DC instrumentation, signaling and alarm circuits for short circuits and extraneous grounds.

6. The District shall be notified if any functional tests fail.
D. **Motor Testing Prior to Energization**

The following tests shall be conducted prior to starting motors for all motors 5 horsepower and larger:

1. Compare equipment nameplate with the Contract Documents and approved shop drawings.
2. Inspect physical and mechanical condition.
3. Inspect anchorage, alignment, and grounding.
4. Perform insulation resistance tests in accordance with IEEE 43 of all motor windings before connecting power conductors to motors. Test duration shall be one minute. Insulation resistance shall be a minimum of 50 megohms at 20°C at test voltage of 1000 V DC.
5. Inspect bolted electrical connections for high-resistance using the calibrated torque-wrench method in accordance with manufacturer's published data.
6. Check all bearings to see if they are properly filled with oil or grease.
7. Check coupling alignment and shaft end play.
8. Rotate the motor shaft by hand or bar to ensure it is free to rotate.

E. **Tests Required to be Performed by Independent Testing Consultant (Testing Consultant)**

1. Subsequent to acceptance of equipment installation by the District, the Contractor shall provide a minimum of ten (10) working days written notice of independent third party testing. All terminations required for NETA testing shall be complete. Energizing of tested equipment is at the discretion of the District and will not take place until passed and documented by the Testing Consultant and reviewed by the District. The entire electrical system shall be tested before energization. If functional testing requires power, the Contractor shall provide temporary power for that purpose. All testing shall be completed prior to equipment start up.

2. All references to NETA in this Section are referring to NETA Standard for Acceptance Testing Specifications.

3. The Testing Consultant shall provide a detailed report on all testing per NETA and Section 16040 for District's approval.
4. In addition to and in conjunction with testing and protective device setting per Section 16040, the following tests shall be performed by the Testing Consultant and witnessed by the Contractor and District:

a. Switchboard and Switchgear Assemblies

Perform all inspections and tests, including all optional tests, listed in Section 7.1 of NETA on all Medium-Voltage Switchboards and Switchgear, and Low-Voltage Switchboards and Switchgear.

b. Transformers, Dry-Type, Air-Cooled

Perform all inspections and tests, including all optional tests, listed in applicable Section 7.2.1.1 or 7.2.1.2 of NETA on all dry type transformers.

c. Transformers, Liquid-Filled

Perform all inspections and tests, including all optional tests listed in Section 7.2.2 of NETA on all liquid-filled transformers.

d. Conductors and Cables, Low-Voltage and Medium-Voltage

Perform all inspections and tests, including all optional tests, listed in Sections 7.3.2 and 7.3.3 of NETA on all low-voltage (600 V maximum) and medium-voltage conductors and cables.

e. Circuit Breakers, Insulated-Case/Molded-Case

Perform all inspections and tests (not including optional tests), listed in Section 7.6.1.1 of NETA on all insulated-case/molded-case circuit breakers 100 A frame and higher.

f. Circuit Breakers, Vacuum, Medium-Voltage

Perform all inspections and tests, including all optional tests, listed in section 7.6.3 of NETA on all medium-voltage circuit breakers.

g. Protective Relays, Electromechanical and Solid-State

Perform all inspections and tests, including all optional tests, listed in Section 7.9.1 of NETA on all electromechanical and solid-state protective relays.
h. Protective Relays, Microprocessor-Based

Perform all inspections and tests listed in Section 7.9.2 of NETA on all microprocessor-based protective relays.

i. Metering Devices, Microprocessor-Based

Perform all inspections and tests listed in Section 7.11 of NETA on all metering devices including power monitors.

j. Grounding Systems

Perform all inspections and tests listed in Section 7.13 of NETA on all grounding systems.

k. Ground-Fault Protection Systems, Low-Voltage

Perform all inspections and tests listed in Section 7.14 of NETA on all ground fault protection systems.

l. Rotating Machinery, AC Induction Motors and Generators

Perform all inspections and tests, including all optional tests, listed in Section 7.15.1 of NETA on all low-voltage AC motors and generators 20 HP and larger.

m. Motor Control, Motor Starters, Low-Voltage

Perform all inspections and tests, including all optional tests, listed in Section 7.16.1.1 of NETA on all motor starters. For item 7.16.1.1.6 "Perform operational tests by initiating control devices," the starter control devices (selector switches, pushbuttons, relays, pilot lights, etc.) and motor control wiring shall be tested by simulating field device controls or signals at starter terminal blocks to simulate actual control functionality. Control functionality shall also be checked during field operation testing as described herein, and in accordance with other Sections of the Detailed Provisions.

n. Motor Control, Motor Control Centers, Low-Voltage

Perform all inspections and tests, including all optional tests, listed in Section 7.16.2.1 of NETA on all MCCs.
General Electrical Requirements
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o. Variable Frequency Drives

Perform all inspections and tests, including all optional tests, listed in Section 7.17 of NETA on all Variable Frequency Drives, except for Section 7.17.2.7 which shall be performed by the manufacturer. For item 7.17.2.8 "Perform operational tests by initiating control devices, the VFD control devices (selector switches, pushbuttons, relays, pilot lights, etc.) and motor control wiring shall be tested by simulating field device controls or signals at starter terminal blocks to simulate actual control functionality." Control functionality shall also be checked during field operation testing as described herein, and in accordance with other Sections of the Detailed Provisions.


Perform all inspections and tests listed in Section 7.22.3 of NETA on all Automatic and Manual Transfer Switches, and Manual Bypass Switches.

q. Setting and Testing of Adjustable/Programmable Protective Devices

The Testing Consultant shall set/program and test the adjustable/programmable protective devices in the field according to applicable NETA and manufacturer's requirements and per Section 16040. Contractor shall provide all software and hardware required to set or program devices. The protective devices shall be tested for operation after completion of device setting and programming.

5. In conjunction with the NETA inspections and tests specified above, each bolted connection shall receive Dykem Orange Torque-Seal, or equal, following verification of proper bolt-torque level.

F. Operational Demonstration Testing

Contractor shall demonstrate that the performance of installed electrical materials and equipment complies with requirements specified in Division 16. Operate equipment through entire no-load to full-load range for not less than 4 hours unless a longer period is specified elsewhere. Immediately correct defects and malfunctions with approved methods and materials in each case, and repeat the demonstration. Operational demonstration testing shall conform to the approved demonstration testing plan.
G. **System Validation Testing**

Unless specified otherwise, test all electrical systems for not less than 7 days (168 hours), with no interruptions except for normal maintenance. System validation testing shall conform to the approved test plan. Coordinate testing with equipment validation testing required under Divisions 11 and 16, and under the Special Conditions.

1. **Testing Materials and Equipment**

   Contractor shall furnish all labor, equipment, and materials for required tests, including all instruments, recorders, gauges, chemicals, power, etc.

2. **Testing Methods**

   Contractor shall perform field tests on equipment as specified in the Special Conditions and/or Specification Sections for the specific equipment. Unless specified otherwise, operate systems continuously (24 hours per day) under constant supervision of trained operators and/or field service engineers. Cause variable speed equipment to cycle through the applicable speed range at a steady rate of change. Induce simulated alarm and distressed operating conditions, and test controls and protective devices for correct operation in adjusting system functions or causing system shutdown. Perform other system validation tests as may be required under other Sections of Division 11 and 16, and under the Special Conditions.

3. **Defects**

   Contractor shall immediately correct all defects and malfunctions disclosed by tests. Contractor shall use new parts and materials as required to perform corrective work, as approved by the District. The specified total test period shall be extended by the interruption time for corrective work.

4. **Test Records**

   Contractor shall continuously record all function and operation parameters during the entire test period. Contractor shall submit complete, well organized, and clearly labeled test data to the District for review and approval.

END OF SECTION 16010
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SPECIFICATIONS - DETAILED PROVISIONS
Section 16040 – Short-Circuit/Coordination Study
and Arc-Flash Hazard Study

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PART 1 - GENERAL

1.01 SUMMARY

A. Contractor shall provide a Short-Circuit and Protective Device Evaluation Study, a Protective Device Coordination Study, and an Arc-Flash Hazard Study, as specified herein.

B. The studies shall be performed for the purposes of estimating the worst case available short-circuit current values and arc-flash incident energy. The studies shall be generated based on information obtained from electrical equipment submittals, actual conductor sizes and lengths for all feeders, utility short circuit current value at the main service switchboard, and information obtained from field reconnaissance of existing equipment/material (if applicable).

C. Contractor shall obtain the short circuit current value at the main service switchboard for the specific project location from the utility. Contractor shall bear all costs associated with obtaining the available short circuit current value.

D. Contractor shall adjust all required protective device settings based on the results of the Protective Device Coordination Study and Arc-Flash Hazard Study.

E. Contractor shall install Arc-Flash and Shock Hazard labels on all electrical equipment, as specified herein.

1.02 DESCRIPTION OF THE WORK

A. Short-Circuit and Protective Device Evaluation Study

1. Contractor shall provide a Short-Circuit and Protective Device Evaluation Study to verify the proposed equipment ratings and protective device ratings.
2. Unless specified otherwise, the scope of the study shall include all proposed distribution equipment supplied under this Contact, as well as all directly affected existing distribution equipment at the District's facility. The study shall include all portions of the existing and proposed electrical distribution system from the electric utility power source(s) and emergency power source(s) down to and including each switchboard, distribution panel, transfer switch (automatic or manual), motor control center, variable frequency drive, distribution panelboard, branch circuit panelboard, busway, enclosed circuit breaker and fused disconnect switch.

B. Protective Device Coordination Study

1. Contractor shall provide a Protective Device Coordination Study to determine and coordinate the selective tripping of protective devices for the proposed equipment.

2. Unless specified otherwise, the scope of the study shall include all proposed distribution equipment supplied under this Contact, as well as all directly affected existing distribution equipment at the District's facility. The study shall include all portions of the existing and proposed electrical distribution system from the electric utility power source(s) and emergency power source(s) down to and including the smallest adjustable trip circuit breaker and fused disconnect switch in the system.

C. Arc-Flash Hazard Study

1. Contractor shall provide an Arc-Flash Hazard Study to determine potential arc-flash incident energies, arc-flash boundaries, shock hazard boundaries; required personal protective equipment (PPE) for all energized electrical equipment; and arc-flash and shock hazard warning labels.

2. Unless specified otherwise, the study shall include all electrical circuits from the electric utility power source(s) and emergency power source(s) to and including all electrical equipment and panelboards rated 208 V and greater.

3. Wherever possible, the proposed electrical equipment shall be designed, manufactured, and supplied to limit the potential arc-flash incident energy to 8 cal/sq cm or less (PPE Category 2). The firm performing the studies shall coordinate with Contractor, the District, and the electrical equipment manufacturers to assist in achieving this requirement.
D. **Field Verification**

Contractor shall provide the services of an independent testing consultant or firm performing the studies to field verify that all protective devices are set in accordance with the accepted short-circuit/coordination study requirements and recommendations. In addition, the consultant or firm shall verify that all arc-flash and stock hazard labels have been installed.

1.03 **RELATED SECTIONS**

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all Sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Division 11 – Equipment

2. Division 16 – Electrical

1.04 **REFERENCE STANDARDS AND CODES**

Unless specified otherwise, all calculations, analyses, and studies, including application of same to equipment and settings shall meet or exceed the applicable requirements of the following standards and codes (latest edition):

A. **Institute of Electrical and Electronics Engineers, Inc. (IEEE):**

1. IEEE 141 – Recommended Practice for Electric Power Distribution for Industrial Plants

2. IEEE 142 – Recommended Practice Grounding of Industrial and Commercial Power Systems


4. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

5. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
6. IEEE 551 – Recommended Practice for Calculating Short-Circuit Currents in Industrial and Commercial Power Systems

7. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems


B. American National Standards Institute (ANSI):

1. ANSI C37.010 – Standard Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

2. ANSI C37.13 – Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures


4. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

C. Code of Federal Regulations:


D. The National Fire Protection Association (NFPA):

1. NFPA 70 - National Electrical Code, latest edition

2. NFPA 70E – Standard for Electrical Safety in the Workplace
1.05 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A. Computer Software Information

Submit product literature/brochure for computer software to be utilized for the studies. Submit computer software statement of compliance with IEEE, ANSI, and NFPA 70E standards and requirements.

B. Qualification Information

Submit qualification information for firm and individual(s) specified in Part 1.06 herein.

C. Utility Information

Submit letter from utility with available short circuit current value at the main service switchboard. As a minimum, the utility letter shall include the following: project address, service voltage and configuration, main service switchboard amperage, short circuit current (3-phase and phase-ground), 3-phase and phase-ground X/R ratios, service transformer kVA and impedance, and service conductor size, number, and length.

D. Study Results and Report

The results of the Short-Circuit and Protective Device Evaluation Study, Protective Device Coordination Study, and Arc-Flash Hazard Study shall be summarized in a well-organized, comprehensive report. The report shall address all study requirements specified in Part 2 herein. A sample outline for the report is provided below:

1. Section 1 - Executive Summary
2. Section 2 - Short-Circuit and Protective Device Evaluation Study
   2.1 Short-Circuit Analysis Objectives
   2.2 System Modeling
   2.3 Short-Circuit Results
   2.4 Equipment, Material, and Protective Device Evaluation
Section 3 - Protective Device Coordination Study

3.1 General Description and Protection Philosophy
3.2 Codes and Standards
3.3 Coordination Objectives
3.4 Coordination Results
3.5 Coordination Recommendations
3.6 Time-Current Characteristic Plots

Section 4 - Recommended Protective Device Settings

Section 5 - Short-Circuit Analysis Computer Reports

5.1 Report Interpretation
5.2 Short-Circuit Input Data Report
5.3 Short-Circuit Analysis Results Report - Utility Source
5.4 Short-Circuit Analysis Results Report - Generator Source
5.5 Short-Circuit Analysis Results Report - Single-Phase

Section 6 - Arc-Flash Hazard Study

6.1 General Description
6.2 Analysis Procedure
6.3 Arc-Flash Analysis Results
6.4 Arc-Flash Analysis Recommendations
6.5 Arc-Flash Labels and Location Drawings

Section 7 - Single Line Diagrams

7.1 Power System Study Diagram
7.2 Reference Drawing Single Line Diagrams

Unless specified otherwise, Contractor shall provide all computer software project study files to the District in electronic format. In addition, a copy of the computer analysis software viewer program shall be provided with the electronic project files, to allow the District to review all aspects of the project and print single line diagrams, arc-flash labels, etc.
E. **Coordination of Studies and Equipment Submittals**

The Short-Circuit and Protective Device Coordination Studies shall be submitted to the District prior to receiving final acceptance of the related equipment shop drawings and prior to equipment fabrication. If formal completion of the studies may cause delay in equipment fabrication and delivery, approval from the District may be obtained for preliminary submittal of sufficient study data to ensure that the proposed equipment ratings and protective device selection/characteristics will be satisfactory.

**1.06 QUALIFICATIONS**

A. The firm and individual(s) performing the specified studies shall be experienced in the application of computer software used for power system studies, and shall have performed studies of similar magnitude on electrical systems using similar equipment and devices.

B. The short-circuit, protective device coordination, and arc-flash hazard studies shall be conducted under the direct supervision and control of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies. Each study report shall be signed and stamped by the Registered Professional Electrical Engineer.

C. Credentials and background of the firm and individual(s) performing the study shall be submitted to the District for approval prior to commencing the work. A minimum of five (5) years of experience in power system analysis is required for the engineer in charge of the project.

**PART 2 – PRODUCTS**

**2.01 GENERAL REQUIREMENTS**

A. Short-Circuit and Protective Device Evaluation Study, Protective Device Coordination Study, and Arc-Flash Hazard Study shall be performed by the same entity.

B. The studies shall be submitted to the District prior to fabrication of any electrical distribution equipment. District's written approval will be required prior to equipment fabrication.

C. Contractor shall be responsible for supplying pertinent electrical system information for proposed equipment/material and existing equipment/material (if applicable).
D. The studies shall include all portions of the electrical system including the electric utility power source and emergency power sources, and contributions from inductive loads on the medium voltage (if applicable) and low voltage (480V) distribution system.

E. All induction motors greater than 50 HP shall be included individually with associated starters and feeder impedance. Unless specified otherwise, all induction motors 50 HP or less and fed from the same bus may be grouped together.

F. Normal system connections and those which result in maximum fault conditions shall be adequately evaluated in the studies.

G. The studies shall be performed using the latest version of the SKM Systems Analysis software (no substitutes). Software shall comply with all applicable IEEE, ANSI, and NFPA 70E standards and requirements.

2.02 DATA COLLECTION

A. Contractor shall be responsible to collect all data as required for the power system studies.

B. The firm performing the system studies shall furnish the Contractor with a listing of the required data immediately after award of the contract and the Contractor shall expedite collection of the data to assure completion of the studies prior to final approval of the distribution equipment shop drawings and/or release of the equipment for manufacture.

C. As a minimum, the following input data shall be collected and tabulated:

1. Product data for overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment names/tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. **Minimum and maximum fault contribution, impedance, and X/R ratio of the electric power utility service transformer.** Rating, type, and settings of the primary overcurrent protective device that protects the service transformer. Conductor data from the protective device to the service transformer. Contractor shall obtain the required electrical service information directly from the electric power utility. Contractor shall be responsible for all coordination and costs associated with obtaining the utility information.

3. **Ampacity and interrupting rating in amperes RMS symmetrical for all switchboards, motor control centers, and panelboards.**

4. **Circuit breaker and fuse current ratings and types within each switchboard, motor control center, panelboard, variable frequency drive, and equipment control panel.**

5. **Manufacturer, frame size, interrupting rating in amperes RMS symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.**

6. **Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.**

7. **Time-current-characteristic curves of protective devices indicated to be coordinated.**

8. **Distribution system transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.**

9. **Standby generator kVA, size, voltage, source impedance, and thermal-damage curve.**

10. **Conductors: conduit material, sizes of conductors, number of conductors per phase, conductor material, insulation, and length.**

11. **Motor horsepower and code letter designation according to NEMA MG 1. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.**

D. **Contractor shall obtain required existing equipment data as necessary to satisfy the study requirements.**
2.03 SINGLE LINE DIAGRAM

A. A single line diagram of the electrical distribution system shall be prepared in hard-copy and electronic-copy formats.

B. As a minimum, the single line diagram shall show the following:

1. All individual switchboard, switchgear, motor control center, and panelboard equipment buses with voltage, bus ampere ratings, and short-circuit current ratings.

2. Circuit breaker and fuses with current ratings, amperes interrupting ratings, and types.

3. Motors labeled with horsepower and code letter designation according to NEMA MG 1.

4. Conductor and bus connections between the equipment.

5. Conductor sizes, number of conductors per phase, conductor material and insulation, conductor length, and conduit material.

6. Transformers labeled with size (kVA), voltage, configuration, impedance, and X/R ratio.

7. Generators labeled with size (kVA), voltage, and source impedance.

8. Transfer switches labeled with ampere rating and short-circuit current rating.

2.04 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

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

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

C. As a minimum, provide the following:

1. Calculation methods and assumptions

2. Selected base per unit quantities
3. Source impedance data, including electric power utility system and motor fault contribution characteristics

4. Tabulations of input data per Part 2.02 and calculated quantities, including fault impedance, X/R ratios, asymmetry factors, motor contributions, generator contributions (if applicable), and symmetrical and asymmetrical fault currents

5. Single line diagram of the system being evaluated with available fault at each bus, and interrupting rating of devices noted

6. Results, conclusions, and recommendations.

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:

1. Electric power utility's supply termination point
2. Incoming switchgear
3. Unit substation primary and secondary terminals
4. Low voltage switchgear and/or switchboard
5. Motor control center
6. Distribution panelboard
7. Branch circuit panelboard
8. Variable frequency drive
9. Standby generator and automatic transfer switch
10. Equipment control panels
11. Other significant locations throughout the system.

E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.
F. Equipment, Material, and Protective Device Evaluations:

1. Evaluate equipment and protective devices and compare to proposed short-circuit ratings.

2. Evaluate adequacy of switchgear, switchboard, motor control center, and panelboard bus bars/bracing to withstand short-circuit stresses.

3. Evaluate adequacy of transformer windings to withstand short-circuit stresses.

4. Evaluate conductors and busways for ability to withstand short-circuit heating.

5. Identify any existing circuit protective devices improperly rated for the calculated available fault current.

6. Tabulate all evaluation results.

2.05 PROTECTIVE DEVICE COORDINATION STUDY

A. Perform the protective device study using the approved computer software program. Utilize the results of the short-circuit analysis. Coordination study shall be performed in compliance with IEEE 399.

1. Model 1/2 cycle network (sub-transient network), 1.5 to 4 cycle network (transient), and 30 cycle network (steady-state network). Calculate 1/2 cycle, 1.5 to 4 cycle, and 30 cycle balanced and unbalanced faults for 3-phase, L-G, L-L, and L-L-G.

2. Calculate the maximum and minimum 1/2 cycle short-circuit currents.

3. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.

4. Calculate the maximum and minimum ground-fault currents.

B. Fault currents and time intervals shall comply with IEEE 241 recommendations.
C. Protect conductors against damage from fault currents according to Insulated Cable Engineers Association (ICEA) Publication P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

D. Protect transformers against damage from through-fault currents according to ANSI C57.109, IEEE C57.12.00, and IEEE 242.

E. Provide computer software generated time-current characteristic (TCC) plots of all overcurrent protective devices on log-log sheets graphically indicating the coordination for all of the key systems.

F. Perform a sequence of operation that evaluates, verifies, and confirms the operation and selectivity of the protective devices for various types of faults via normalized TCC plots and the single-line diagram. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

G. Establish settings and/or ratings of overcurrent protective devices to achieve selective coordination between devices. Graphically illustrate that adequate time separation exists between devices installed in series, including electric power utility's upstream devices. Prepare separate sets of plots for the switching schemes and for emergency periods where the power source is via the emergency standby generator(s).

H. On each TCC plot, include reference voltage, a complete title, and single line diagram with legend identifying the specific portion of the system covered.

I. Identify the device associated with each curve by device designation/tag, manufacturer, type, and function. Terminate the protective device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device will be exposed.

J. The electric power utility's relay, fuse, or protective device shall be plotted with all load protective devices at the same voltage.

K. Transformer primary protective device, transformer magnetic inrush, transformer ANSI withstand points, secondary voltage fuse or circuit breaker and largest feeder fuse or circuit breaker shall be plotted at the secondary voltage.

L. Fuse curves shall include no damage, melting, and clearing curves as applicable.
M. Circuit breaker curves shall include complete operating bands, terminating with the appropriate available short-circuit current.

N. When the main circuit breaker is provided with an arc-flash reduction maintenance system to reduce the arc fault level, both settings shall be included in the study.

O. Low voltage circuit breakers with adjustable overcurrent protection shall have instantaneous, short delay, and long-time pick-up identified on the plot. Low voltage circuit breakers with ground fault protection shall have ground fault trip settings, ground fault ampere, and time delay settings identified on the plot. Sensor or monitor rating shall be stated for each circuit breaker. All regions of the circuit breaker curve shall be identified.

P. Feeder circuit breakers shall have the time-damage curve of the feeder conductors plotted to indicate protection of the conductor insulation at the total clearing time of the circuit breaker or fuse. This time-damage point shall be calculated for the specific parameters of conductor insulation used, with average 3 phase RMS asymmetrical amperes at 1/2 cycle calculated using actual resistance and reactance values of the source plus all motor contributions which exist at the load end of the feeder conductors. Conductor initial temperature and conductor maximum transient temperature for short-circuits, as recommended by ICEA, shall be indicated.

Q. The coordination plots shall include significant motor starting characteristics and large motor protective devices.

R. As a minimum, TCC coordination plots shall be provided for the following:

1. Electric power utility’s overcurrent protective device

2. Medium voltage equipment overcurrent relays

3. Medium and low voltage fuses including manufacturer’s minimum melt, total clearing, tolerance, and damage bands

4. Low voltage circuit breakers and fuses, including manufacturer’s tolerance bands

5. Transformer full-load and 150, 400, or 600 percent currents, magnetizing inrush current, and ANSI through-fault protection curves

6. Conductor damage curves
7. Ground fault protective devices, as applicable

8. Pertinent motor starting characteristics and motor damage points. For motor control circuits, show motor control center full-load current plus symmetrical and asymmetrical of the largest motor starting current and time to ensure protective devices will not trip during major or group start operation.

9. Pertinent generator short-circuit decrement curve and generator damage point, where applicable. Provide phase and ground coordination of the generator protective devices. Obtain the required input information from the generator manufacturer and include the generator actual impedance value, time constants, and current boost data in the study. Do not use typical values for the generator.

10. Other system load protective devices, including branch circuits and feeder circuit breakers in each motor control center, and main circuit breaker in each branch panelboard.

S. A summary tabulation shall be provided listing the designation/tag, manufacturer, and type for all overcurrent and ground fault protective devices, and all recommended settings of each adjustable band included for each device.

T. Provide an evaluation of the degree of system protection and service continuity possible with the overcurrent devices supplied.

2.06 ARC-FLASH HAZARD STUDY

A. The arc-flash hazard study shall be performed according to the IEEE 1584 guidelines and equations presented in NFPA 70E-2015, Annex D. The analysis shall be performed in conjunction with the Short-Circuit and Protective Device Evaluation Study, and the Protective Device Coordination Study.

B. The flash-protection boundary and the incident energy shall be calculated at all equipment locations in the electrical distribution system where work could be performed on energized parts, including, but not limited to, the following: switchboards, switchgear, motor control centers, panelboards, busway and splitters, and equipment control panels.

C. The Arc-Flash Hazard Study shall include all medium voltage, locations, all 480V locations, and all 240V and/or 208V locations. In addition, the Arc-Flash Hazard Study shall include all DC locations of 50V or greater.
D. Safe working distances shall be based upon the calculated arc-flash boundary considering an incident energy of 1.2 cal/sq cm.

E. When appropriate, the short-circuit calculations and the clearing times of the overcurrent protective devices shall be retrieved from the short-circuit and protective device coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

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

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

1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.

2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

H. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash-protection boundary shall include both the line and load side of the main breaker.
I. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions shall be included in the fault calculation.

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

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

L. Determine incident energy and arc-flash PPE requirements for each equipment location. For main circuit breakers with arc-flash reduction maintenance systems, determine two (2) incident energies (one for normal duty and one for maintenance duty).

M. Calculate shock hazard approach boundaries (limited approach boundary and restricted approach boundary) for each equipment location.

N. Provide recommendations to reduce arc-flash hazard energy and exposure.

O. Coordinate with manufacturers/suppliers of the electrical equipment.

2.07 STUDY DATA

The results of all study calculations, analyses, evaluations, and determinations specified in Part 2 herein shall be presented in a detailed, comprehensive report. In addition, data from the computer software analyses shall be included in the study report along with data evaluation and recommendations. Computer analysis data, data evaluation, and recommendations shall include, but not be limited to, the following:

A. Study Input Data

1. Feeder input data including feeder type (cable or bus), size, length, number per phase, conduit type (magnetic or non-magnetic) and conductor material (copper or aluminum).

2. Transformer input data, including winding connections, secondary neutral-ground connection, primary and secondary voltage ratings, kVA rating, impedance, percent taps and phase shift.
3. Reactor data, including voltage rating, and impedance.

4. Generation contribution data, (synchronous generators and electric power utility), including short-circuit reactance ($X''d$), rated MVA, rated voltage, three-phase and single-line to ground contribution (for electric power utility sources) and $X/R$ ratio.

5. Motor contribution data (induction motors and synchronous motors), including short-circuit reactance, rated horsepower or kVA, rated voltage, and $X/R$ ratio.

B. Short-Circuit Study

1. Low Voltage Fault Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
   a. Voltage (600V and less)
   b. Calculated fault current magnitude and angle
   c. Fault point $X/R$ ratio
   d. Equivalent impedance

2. Momentary (First Half-Cycle) Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
   a. Voltage (greater than 600V)
   b. Calculated symmetrical fault current magnitude and angle
   c. Fault point $X/R$ ratio
   d. Calculated asymmetrical fault currents
      • Based on fault point $X/R$ ratio
      • Based on calculated symmetrical value multiplied by 1.6
      • Based on calculated symmetrical value multiplied by 2.7
   e. Equivalent impedance
3. Interrupting Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:

a. Voltage (greater than 600V)

b. Calculated symmetrical fault current magnitude and angle

c. Fault point X/R ratio

d. No AC decrement (NACD) ratio

e. Equivalent impedance

f. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a symmetrical basis

g. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a total basis.

C. Protective Device Coordinating Study:

1. Recommendations for Phase and Ground Relays:

a. Current transformer ratio

b. Current setting

c. Time setting

d. Instantaneous setting

e. Recommendations on improved relaying systems, if applicable.

2. Recommendations for Circuit Breakers:

a. Adjustable pickups and time delays (long time, short time, ground)

b. Adjustable time-current characteristic

c. Adjustable instantaneous pickup

d. Recommendations on improved trip systems, if applicable.
D. **Arc-Flash Hazard Study:**

1. **Incident Energy Calculations:**
   a. Arcing fault magnitude
   b. Protective device clearing time
   c. Duration of arc
   d. Incident energy

2. **Arc-Flash Protection Boundary Calculations and Recommendations:**
   a. Arc-flash boundary
   b. Shock hazard approach boundaries
   c. Personal protective equipment
   d. Recommendations for arc-flash energy reduction.

**2.08 IMPLEMENTATION OF STUDY RESULTS**

Prior to fabrication, Contractor shall coordinate the study results with the manufacturers and suppliers of electrical equipment to incorporate the recommendations and modifications therein.

**2.09 ARC-FLASH AND SHOCK HAZARD LABELS**

A. **General**

1. Labels shall be 4" x 6" thermal transfer type labels of UV resistant high adhesion polyester. Labels shall be machine printed, with no field markings.

2. Labels shall comply with the requirements of the NEC, NPFA 70E, and ANSI Z535.4.

3. All labels shall be based on recommended overcurrent protective device settings and shall be provided after the results of the analyses have been accepted by the District and after any system changes, upgrades or modifications have been incorporated into the system.
4. In general, the arc-flash labels shall be based on the maximum calculated incident energies for the worst case operating scenario. However, where arc-flash reduction maintenance systems are specified, provide two (2) sets of arc-flash labels (one for normal duty and one for maintenance duty).

5. The firm performing the Study shall provide all labels. Equipment elevations drawings showing the location of each label shall be prepared by the firm performing the Study.

6. For outdoor electrical panels with interior enclosures and outer NEMA 3R wrappers, labels shall be provided on both outer and inner doors, as follows:
   a. For incident energy levels less than 40 cal/sq cm, each outer door section shall be provided with a warning label stating "WARNING, ARC-FLASH AND SHOCK HAZARD, APPROPRIATE PPE REQUIRED". The label color scheme shall match the inner arc-flash warning label.
   b. For incident energy levels greater than 40 cal/sq cm, each outer door section shall be provided with a danger label stating "DANGER, ARC-FLASH AND SHOCK HAZARD, NO SAFE PPE EXISTS, ENERGIZED WORK PROHIBITED". The label color scheme shall match the inner arc-flash danger label.
   c. Inner doors shall be provided with arc-flash labels as specified in Parts B and C below.

7. Labels shall be provided for each switchboard, distribution panel, transfer switch (automatic or manual), motor control center, variable frequency drive, distribution panelboard, branch circuit panelboard, busway, enclosed circuit breaker and disconnect switch in a readily visible location in accordance with NEC and OSHA requirements.

8. Where incident energy levels vary across a panel line-up, such as a motor control center, a separate label shall be provided for each section or compartment with a different incident energy level. As a minimum, labels shall be installed every four feet.

B. Warning Labels

1. Warning labels shall be white with an orange stripe and black letters. A sample warning label is presented at the end of this Section.
2. Warning labels shall include the following information:

a. "WARNING, ARC-FLASH AND SHOCK HAZARDS, APPROPRIATE PPE REQUIRED".

b. Arc-flash hazard boundary.

c. Available incident energy (cal/sq cm) and working distance.

d. Recommended (minimum) PPE from NFPA Table 70E H.3(b)

e. Maximum available fault current (Isc).

f. Shock hazard when cover is removed.

g. Glove class.

h. Limited approach distance.

i. Restricted approach distance.

j. Equipment description and location.

k. Protective device description.

l. Operating scenario.

m. Firm identification (prepared by).

n. Label preparation date.

C. Danger Labels

1. Danger labels shall be white with a red warning stripe and black letters. A sample danger label is presented at the end of this Section.

2. Danger labels shall include the following information:

a. "DANGER, ARC-FLASH AND SHOCK HAZARDS, ENERGIZED WORK PROHIBITED".

b. Arc-flash hazard boundary.

c. Available incident energy (cal/sq cm) and working distance.
d. No safe PPE exists – Do not work on equipment while energized.

e. Available fault current (Isc).

f. Shock hazard when cover is removed.

g. Glove class.

h. Limited approach distance.

i. Restricted approach distance.

j. Equipment description and location.

k. Protective device description.

l. Operating Scenario.

m. Firm identification (prepared by).

n. Label preparation date.

PART 3 - EXECUTION

3.01 PROTECTIVE DEVICE SELECTION AND SETTING

A. Field setting of the protective devices shall be performed as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short-circuit study, protective device evaluation study, and protective device coordination study. Confirmation of protective device selection and performance of device field setting shall be witnessed and verified by the testing consultant performing electrical system testing (reference Specification Section 16010) or by the firm performing the studies.

B. Contractor shall set all relays, overcurrent devices and ground fault protection devices, and confirm selection of fuse overcurrent devices as follows:

1. Relays: Reset all adjustable relay settings from factory defaults settings to the settings recommended in the studies specified herein.

2. Circuit Breakers: Reset all adjustable trip settings from factory default settings to the settings recommended in the studies specified herein.
3. Ground Fault Protection Devices: Reset all adjustable device settings from the factory defaults settings to the settings recommended in the studies specified herein.

4. Fuses: Confirm that fuse types installed on the project are as recommended in the studies specified herein.

C. Necessary field adjustments of devices and minor modifications to equipment to accomplish conformance with the approved studies shall be performed at no additional cost to the District.

D. Contractor shall verify the proper short-circuit duty and amperage rating of all protective devices and bussing. Equipment short-circuit duty and amperage ratings shall be in accordance with the Drawings and equipment specifications, and shall meet or exceed the ratings recommended in the studies specified herein.

3.02 ARC-FLASH AND SOCK HAZARD LABEL INSTALLATION

A. Affix arc-flash and shock hazard labels to all electrical equipment as required by NFPA 70 and NFPA 70E.

B. Install labels in accordance with the approved label location drawings and as specified herein.

3.03 FIELD REPORT

The firm witnessing the confirmation of protective device selection and performance of device field setting shall provide a detailed report showing that selections and settings of protective devices are in compliance with the studies and requirements specified herein. In addition, the report shall include a photographic record of all installed arc-flash labels, including locations. The report shall be submitted to the District for acceptance as a submittal document.
ARC-FLASH LABEL EXAMPLES

WARNING

Qualified Persons Only

Arc-Flash and Shock Hazards
Appropriate PPE Required

REVIEW SAFE WORK PRACTICES PRIOR TO WORK

44 in Arc-Flash Hazard Boundary
7.1 cal/cm² Arc-Flash Incident Energy at Work Distance: 18 inches
5.85 kA Maximum Available Fault Current

Recommended (Minimum) PPE: Arc-rated long sleeve shirt and arc-rated pants, or arc-rated coverall and/or arc-flash suit. Arc-rated arc-flash suit hood, arc-rated gloves, arc-rated jacket, parka, or rainwear. Hard hat, arc-rated hard hat liner, safety glasses, hearing protection, arc-rated gloves, and leather footwear.

480 VAC Shock Hazard when Cover is Removed
00 Glove Class

42 in Limited Approach
12 in Restricted Approach

Equipment/Device Name: MCC-2A
Feed From: MDP-1
Scenario 2 - Normal Power

Study Performed by: ACME Flash, Inc.
Prepared: 02/12/16

DANGER

Arc-Flash and Shock Hazards
Energized Work Prohibited

207 in Arc-Flash Hazard Boundary
65 cal/cm² Arc-Flash Incident Energy at Work Distance: 18 inches
43.8 kA Maximum Available Fault Current

Recommended (Minimum) PPE: No Safe PPE Exists - Do Not Work On Equipment While Energized!

480 VAC Shock Hazard when Cover is Removed
00 Glove Class

42 in Limited Approach
12 in Restricted Approach

Equipment/Device Name: Main CB
Feed From: Service Switchboard
Scenario 2 - Normal Power

Study Performed by: ACME Flash, Inc.
Prepared: 02/12/16

END OF SECTION
# SPECIFICATIONS - DETAILED PROVISIONS
## Section 16050 - Basic Electrical Materials and Methods

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PART 1 - GENERAL

1.01 SCOPE

A. This section specifies the requirements for the fabrication, assembly, delivery, testing, and installation of electrical equipment and material necessary for the electrical work of this Contract.

B. Contractor shall furnish all labor, supervision, materials, equipment, tests and services to install electrical equipment and material, as specified herein and shown on the Drawings.

1.02 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Sections of the Specifications specifying equipment and/or systems requiring electrical work, including basic electrical materials and equipment.
2. Division 16 – Electrical
3. Division 17 – Instrumentation and Controls

1.03 STANDARDS AND CODES

A. All materials and equipment, including installation of same, shall meet or exceed the applicable requirements of the following standards and codes (latest edition):

1. ANSI American National Standards Institute
2. ASTM American Society for Testing and Materials
4. ICEA Insulated Cable Engineers Association
5. IEEE Institute of Electrical and Electronic Engineers
6. IESNA  Illuminating Engineering Society of North America
7. NEIS  National Electrical Installation Standards
8. NEMA  National Electrical Manufacturers Association
9. NEC  National Electrical Code (NFPA 70)
10. NETA  National Electric Testing Association (NETA)
11. NFPA 70E  Standard for Electrical Safety in the Workplace
12. NIST  National Institute of Standards and Technology
13. OSHA  Occupational Safety and Health Administration (Federal and State)
14. UL  Underwriters Laboratories

B. Underwriters' Laboratories Approval: All material and equipment furnished by the Contractor shall be listed by and shall bear the label of Underwriters Laboratories (UL) or Edison Testing Labs (ETL).

C. All electrical materials and equipment, and the design, construction, and installation thereof, shall comply with all applicable provisions of the Federal Occupational Safety and Health Administration (OSHA), and California Occupational Safety and Health Administration (Cal OSHA).

D. Where the Drawings or these Specifications call for material, equipment and workmanship to be of better quality or higher standard than required by the above standards and codes, and applicable rules and regulations, then said Drawings and Specifications shall prevail. Nothing on the Drawings or in these Specifications shall be construed to permit work in violation of the above standards and codes.

E. In the event of a conflict or disagreement between the Drawings and Specifications; and standards; codes; federal, state, and local laws and ordinances; utility company regulations; or industry standards; the most stringent requirements shall govern. The Contractor shall promptly notify the District in writing of such differences.
1.04 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

Submit for the District's approval material lists, shop drawings, factory test reports and technical data to the extent required in this Section, Section 16010, and the General Conditions.

A. Shop Drawings

Contractor shall submit complete information, drawings, and technical data for all material and equipment, including, but not limited to, the following:

1. Manufacturer’s product literature and specifications for all material and equipment required for the project. Product literature and specifications shall be marked to clearly identify all applicable information and crossing out all inapplicable information. Applicable sizes, model numbers, and options shall be clearly marked. Sufficient data and detail shall be provided to demonstrate compliance with these Specifications.

2. Interconnection wiring diagrams (loop diagrams) showing all interconnections between equipment, control panels, RTU, electrical switchgear, MCCs, field instrumentation, etc. Diagrams shall be provided with wire numbers and terminal block numbers.

3. Electrical control drawings, including complete control ladder diagrams and complete interconnect diagrams with appropriate wire and terminal numbering. Control ladder diagrams shall be provided with numbers for each line, including references to the line number where contacts for each relay are shown. Ladder diagrams shall show wire numbers, terminal blocks, and terminal block numbers.

4. Schematic wiring diagrams for all local control stations. Schematic wiring diagrams shall clearly identify internal and external devices, and all remote contacts and signals.

5. Nameplate schedule for all local control stations, including nameplate material, lettering height, and proposed inscriptions.

6. Conduit tag schedule for all conduit tags, listing the proposed engraving for each conduit tag.

7. Conductor identification marker schedule for all field conductors, listing the proposed identification for each conductor at each terminal point.
8. Pull box and manhole schedule, listing all proposed pull boxes and manholes. Schedule shall include structure size and depth, type of cover, cover load rating, and special features (if any).

9. Duct bank drawings and cross sections of all electrical duct banks (two (2) conduits or more). Cross sections shall be provided at each pull box and manhole (entrance and exit). Each conduit in the duct bank cross section shall be labeled. Elevations to the nearest 0.1' shall be provided at the top and bottom of each duct bank cross section.

10. Drawings for all grounding work not specifically shown on the Contract Drawings.

B. Operation and Maintenance Manuals

Contractor shall submit detailed Operation and Maintenance Manuals for each item of equipment in accordance with the General Conditions.

C. Record Drawings

Contractor shall maintain and keep current a complete record set of construction drawings showing every change from the Contract Drawings and Specifications and the exact locations, sizes, and types of equipment and material installed. Record drawings shall show all conduit runs (sizes and number), circuits, and conductors (sizes and numbers). Record drawings shall show depths and routing of all concealed and belowgrade electrical installations. Record drawings shall be available to the District during construction and shall be delivered to the District upon project completion.

1.05 COORDINATION OF WORK AND TRADES

A. Electrical work shall be performed in cooperation with all other trades so that a neat and orderly arrangement of the work as a whole shall be obtained.

B. Prior to commencing work, the Contractor shall verify with the equipment manufacturers that equipment dimensions and arrangements will allow for equipment installation in the spaces shown on the Drawings for all motor control centers, variable frequency drives, switchboards, panelboards, control panels, transformers, and other major items of electrical equipment, and that the installation indicated will provide for all required ventilation, clearances, access, and work space.
C. Before installing any equipment, materials, or raceways, the Contractor shall carefully examine the complete set of Drawings and Specifications, and approved equipment shop drawings and confirm connection methods, and all dimensions and space requirements. Contractor shall confirm size and type of equipment conduit connectors with proposed conduit material and sizes. In addition, Contractor shall confirm stub-up areas beneath equipment panels and areas marked for direct conduit connection, with the proposed number and size of conduit.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Delivery

Deliver electrical materials and equipment in manufacturer's original cartons and containers with seals intact. Deliver conductors on sealed reels. Deliver large multi-component equipment in sections to facilitate field handling and installation.

B. Storage

Unless designed for outdoor exposure, store electrical equipment and material on the ground and under cover. Equipment and material shall be protected from weather, corrosion, contamination, and deterioration. Dents, marred finishes, and other damage shall be repaired to its original condition or replaced as directed by the District.

C. Handling

All equipment and material shall be handled in accordance with the manufacturer's recommendations. Large or heavy items shall be lifted at the points designed by the manufacturer. Equipment and material shall be handled and installed as necessary to prevent damage.

PART 2 - PRODUCTS

2.01 GENERAL

Except as may be specifically indicated otherwise, materials and products furnished under this section shall be new and in accordance with the standards as herein before specified. Products used for the same purpose shall be of the same manufacturer and make. Outdoor equipment, fixtures and wiring devices shall be of approved weatherproof construction or shall be in weatherproof enclosures.
A. **Standard Products**

Materials and products submitted for approval shall be the cataloged products of companies regularly engaged in the manufacture of such items, shall be the latest standard design that conforms to the specification requirements and shall essentially duplicate materials and products that have been in satisfactory use for at least 2 years.

B. **Approved Manufacturers**

Wherever on the Drawings or in the Specifications, materials or equipment are identified by the names of one or more manufacturers, it is intended that only these manufacturers will be acceptable. Equal materials or equipment of other manufacturers may be submitted for consideration by the District at least 30 days prior to bid.

### 2.02 CONDUCTORS AND CABLES

A. **General**

Conductors and cables shall be new, single conductor, copper, not smaller than #14 AWG (except shielded control wire) unless indicated otherwise on the Drawings. Aluminum conductors and cables are not acceptable.

Conductor insulation shall bear manufacturer's trademark, insulation designation, voltage rating, and conductor size at regular intervals. Each type of conductor or cable shall be the product of a single manufacturer.

B. **Conductors Smaller than 250 MCM**

1. **Above Grade**

   Conductors smaller than 250 MCM for power service, power feeders, power circuits, lighting feeders, lighting circuits, and control circuits shall be stranded copper, rated 600 volt, with 75°C THWN insulation, UL approved, for installation underground, in concrete, in masonry, or in wet locations.

2. **Below Grade**

   Conductors smaller than 250 MCM for power service, power feeders, power circuits, lighting feeders, lighting circuits, and control circuits shall be stranded copper, rated 600 volt, with 90°C XHHW-2 insulation, UL approved, for installation underground, in concrete, in masonry, or in wet locations.
C. **Conductors 250 MCM and Larger**

1. **Above Grade:**
   Conductors 250 MCM and larger shall be stranded copper, rated 600 volt, with 75°C THHN or THWN insulation, UL approved, for installation underground, in concrete, in masonry, or in wet locations.

2. **Below Grade:**
   Conductors 250 MCM and larger shall be stranded copper, rated 600 volt, with 90°C XHHW-2 with XLP insulation, UL approved, for installation underground, in concrete, in masonry, or in wet locations.

D. **High Temperature Conductors**

High temperature conductors shall be provided where indicated on the Drawings. High temperature conductors shall be stranded copper, rated 600 volt, with 90°C THHN insulation, UL approved. High temperature conductors shall only be utilized to compensate for ambient temperature correction factors and adjustment factors per NEC Article 310 with conductors sized based on 75°C ampacity per NEC Tables 310.15(B)(16) and 310.15(B)(17), unless all electrical system connectors, terminals, and lugs for high temperature conductors are rated 90°C.

E. **Ground Conductors and Neutral Conductors**

Ground conductors shall be provided for required ground wiring.

Equipment ground conductors shall be stranded copper, rated 600 volt, with 75°C THWN insulation, UL approved, for installation underground, in concrete, in masonry, or in wet locations. Equipment ground conductors shall be identified by a continuous green insulation color.

Structure and building ground system conductors shall be stranded bare copper. Minimum conductor size shall be #1/0 AWG.

Neutral conductors shall be stranded copper, rated 600 volt, with 75°C THWN insulation, UL approved, for installation underground, in concrete, in masonry, or in wet locations. Neutral conductors shall be identified by a continuous white insulation color.
F. Instrumentation Signal Cables

Instrumentation signal cables shall be single twisted pair or multi-twisted pairs of stranded, 600 volt, copper cables with 15 mil polyvinyl chloride insulation over each conductor, overall aluminum-mylar tape shield, overall tinned copper drain wire and 45 mil minimum polyvinyl chloride jacket overall. Twisted pair cables that are required to be shielded, shall have aluminum-mylar tape shields and tinned copper drain wires over individual twisted pairs of cable. Single twisted pair cables shall be #16 AWG minimum. Unless indicated otherwise on the Drawings, instrumentation signal cable shall be used for all 4-20 mA signals. Cables shall be manufactured by Belden, Okonite, or equal.

G. Fine Stranded Conductors

Fine stranded conductors, Class C and higher (such as DLO cable), shall only be installed where specifically indicated on the Drawings. All terminations of fine stranded conductors shall be provided with copper flex-cable compression adapters to properly confine the fine strands and prevent overheating of the connection and wire pullout from mechanical lugs. The flex-cable compression adapters shall fit mechanical set-screw mechanical lug type connectors and shall be sized for the full current carrying capacity of the cable. The adapters shall be provided a flared barrel-opening to allow easy cable insertion. The adapter shall be constructed of wrought copper with pin of Class B stranded copper conductor, rated for 600V and 105°C cable, and shall be UL listed. Pin length shall be sufficient to allow full engagement into the mechanical lug. Flex-cable copper compression adapters shall be Shoo-pin PT-FX Series, as manufactured by Greaves Corporation, or equal.

Welding cable shall not be used unless factory installed.

H. Color Coding

System conductors shall be factory color coded by integral insulation pigmentation with a separate color as specified herein. Conductors #6 AWG and larger may be color coded with an approved colored marking tape at all terminations and in all junction boxes, pull boxes, and manholes. Each voltage system shall have a color coded system that shall be maintained throughout the project. Approved conductor colors are as follows:

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<th>Service</th>
<th>Color</th>
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<tbody>
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<tr>
<td></td>
<td>Phase B</td>
<td>Orange</td>
</tr>
<tr>
<td></td>
<td>Phase C</td>
<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>White</td>
</tr>
</tbody>
</table>

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- **Power System**
- **Service**
- **Color**
120/208/240V, 3 Phase, 4 Wire
Phase A  Black
Phase B  Red
Phase C  Blue
Neutral  White

All Equipment  Ground  Green
All System  Ground  Bare Copper

Control System  Service  Color
PLC (Status and Control)  Digital Input  Blue
                         Digital Output  Brown

120V
Positive  Red
Negative  White

24V
Positive  Yellow
Negative  Blue

12V
Positive  Red
Negative  Black

120V
Switched Leg  Not Black, Red or Blue

277V
Switched Leg  Not Brown, Orange, or Yellow

2.03 CONDUCTOR AND CABLE CONNECTORS

Connectors shall be provided for splices and terminal connections of all copper conductors and cables. The connector shall be designed to fit the conductor to which it shall be connected.

A. Compression Connectors

1. Connectors for #8 AWG and larger conductors, 600 V rated, shall be non-insulated compression type constructed of copper and tin-plated. Connectors shall be one-hole, flat-tongue style lugs for terminal connections, and two-way sleeves for splice connections.

Non-insulated compression type splice connectors shall be taped with two layers of half lapped liner-less rubber splicing tape and provided with a cold shrink
connector insulator sleeve (pre-slipped over the conductor) over the splice connector. Cold shrink insulators shall be as manufactured by 3M Company, or equal.

2. Connectors for #10 AWG and smaller conductors, 600 V rated, shall be pre-insulated compression type constructed of copper and tin-plated. Connectors shall be split-tongue type for terminal connections, and two-way sleeves for splice connections.

3. Connectors shall be similar to Thomas & Betts "Sta-Kon", or equal. Connectors shall be installed using manufacturer’s crimping tools and accessories.

4. Waterproofed splices shall be constructed with cold shrink insulators encapsulated in epoxy resin. Epoxy resin splice kits shall be 3M Scotchkote 82 Series, or equal.

B. Tapered Coil Spring Connectors

Connectors shall have live coil springs, flame retardant thermoplastic shells rated for 105 ºC, and shall be UL listed. Connectors shall be provided for #10 AWG and smaller conductors for lighting and receptacles. Connectors shall be as manufactured by Buchanan, Thomas & Betts, Ideal, or equal.

C. Shielded Cable Terminations

Shielded cable shall be terminated with pre-assembled stress cones. Stress cone terminations shall be IEEE Class 1 molded rubber type. Stress cone terminations shall be approved by the cable manufacturer. Contractor shall submit its proposed termination procedures with shop drawings for shielded cable. Stress cone terminations shall be as manufactured by 3M Company, Raychem, or equal.

D. Electrical Tape

Electrical tape shall be premium grade, 7 mil thick, all-weather vinyl-insulating tape. Tape shall be designed to perform continuously in ambient temperatures up to 105 ºC, and shall be resistant to abrasion, moisture, alkalies, acids, corrosion, and varying weather conditions (including ultraviolet exposure). The tape shall be compatible with synthetic cable insulations, jackets and splicing compounds, and shall be UL listed. The tape shall be Scotch Super 33 Plus, or equal.

2.04 CONDUCTOR AND CABLE MARKERS

Markers shall be provided to identify all conductors and cables at equipment terminals, and in junction boxes, pull boxes, and manholes. The conductor and cable markers shall be one uniform standardized marking system. Heat shrinking of the markers and clear tubing shall be in
accordance with manufacturer's specifications. The field installed conductor and marker number shall be labeled with the same number as the terminal it is connected to.

A. **Markers**

The marking system shall consist of heat shrinkable flame retarded identification sleeves that fit tightly over the conductor or cable to be marked. Marker sleeves shall be made of a seamless cross-linked polyolefin with a 3 to 1 shrink ratio.

Conductor and cable marker system shall be UL recognized to Standard 224, MIL-M-81531. Markers shall be smear resistant prior to shrinking and achieve a permanent mark when shrunk, without the need for permatizing equipment. Markers shall be seamless. Markers shall be resistant to common industrial fluids including Freon TF, Isopropyl Alcohol and Ethylene Glycol. Markers shall have a temperature range of -30°C to 105°C and a dielectric strength of 500 V/mil minute. Marks shall be legible after 20 eraser rubs and 30 solvent brush strokes. The markers shall be suitable for indoor or outdoor use. The conductor and cable marker system shall be as manufactured by Raychem/Kroy Cable Marking, or Brady-Permasleeve White Polyolefin (B-342), or equal. Heat shrinkable thermoplastic tags are not acceptable.

B. **Clear Tubing**

Adhesive type cable markers are not acceptable by themselves. To provide a long-term permanent marker in high ambient temperatures, a translucent (clear) shrink tube shall be placed over each wire marker (extending past both edges of adhesive wire marker) and heat shrunk. The clear tube shall be suitable for high temperature performance, abrasion resistance and cut-through resistance and resistant to chemicals and solvents. The clear tubing shall meet the high temperature performance that meets or exceeds military industrial standards: MIL-1-23053, Test C, with UL VW-1 ratings. Operating temperature range shall be -55°C to 175°C. Product shall be Kynar as manufactured by Raychem, or equal.

### 2.05 METAL CONDUITS

Each length of conduit shall bear the manufacturer’s name and UL label. Minimum conduit size shall be 3/4", unless noted otherwise. Conduit ends shall be threaded. Unless specified otherwise, elbows shall be standard radius sweeps meeting the requirements of the NEC.

A. **Rigid Galvanized Steel (RGS) Conduit**

1. RGS conduit, couplings, elbows, bends, and nipples shall be in accordance with ANSI C80.1 and UL 6, and shall be hot-dipped galvanized inside and out.
2. RGS conduit ends shall be threaded. Threads shall be hot galvanized after cutting. Color-coded end caps shall be provided to protect conduit threads. Thread-less fittings are not acceptable. A hot-dipped galvanized threaded coupling shall be furnished with each length of conduit.

3. All conduit cut ends shall be reamed or otherwise finished to remove rough edges. Where conduit is threaded in the field, a standard cutting die with NPT tapered threads (3/4-in. taper per foot) shall be used. Running threads are not acceptable.

4. Conduit, couplings, elbows, bends, and nipples shall be as manufactured by Allied Tube & Conduit, Wheatland Tube, Conduit Pipe Products Company, or equal.

B. PVC Coated Rigid Galvanized Steel (PVC-RGS) Conduit

1. PVC-RGS conduit, couplings, elbows, bends, nipples, and connectors shall be in accordance with ANSI C80.1, UL 6 A, and NEMA RN-1, and shall be hot-dipped galvanized inside and out. A PVC coating of 40 mils (minimum) thickness shall be bonded to the outer galvanized surface of the conduit and a urethane coating of 2 mils (minimum) thickness shall be applied to the interior surface of the conduit. The bond between the PVC coating and the conduit surface shall be greater than the tensile strength of the plastic.

2. PVC-RGS conduit ends shall be threaded. A PVC-coated threaded coupling shall be furnished with each length of conduit. A PVC sleeve equal to the OD of the conduit shall extend 2 inches from each end of the coupling.

3. Factory threaded ends shall be provided a urethane coating. Field cut threads shall be coated as specified in Part 3 herein.

4. Conduit, couplings, elbows, bends, nipples, and connectors shall be as manufactured by Ocal, Perma-Cote, Rob-Roy, or equal.

C. Rigid Aluminum (RA) Conduit

1. RA conduit, couplings, elbows, bends, and nipples shall be in accordance with ANSI C80.5 and UL 6A. RA conduit, couplings, elbows, bends, and nipples shall be constructed of aluminum 6063 alloy in temper designation T-1.

2. RA conduit ends shall be threaded. A threaded coupling shall be furnished with each length of conduit. A graphite based lubricant shall be factory applied to the threads at each end of the conduit. Color-coded end caps shall be provided to protect threads.
3. All conduit cut ends shall be reamed or otherwise finished to remove rough edges. Where conduit is threaded in the field, a standard cutting die with tapered threads (3/4-in. taper per foot) shall be used. Running threads are not acceptable.

4. All RA conduit in direct contact with the ground, concrete, or grout shall be PVC coated as specified herein. Alternatively, RA conduit may be protected by double wrapping with 20 mil PVC tape.

5. RA conduit, couplings, elbows, bends, and nipples shall be as manufactured by Allied Tube & Conduit, Wheatland Tube, Conduit Pipe Products Company, or equal.

D. PVC Coated Rigid Aluminum (PVC-RA) Conduit

1. PVC-RA conduit, couplings, elbows, bends, nipples, and connectors shall be in accordance with ANSI C80.5, UL 6A and NEMA RN-1. A PVC coating of 40 mils (minimum) thickness shall be bonded to the outer surface of the conduit and a urethane coating of 2 mils (minimum) thickness shall be applied to the interior surface of the conduit. The bond between the PVC coating and the conduit surface shall be greater than the tensile strength of the plastic.

2. PVC-RA conduit ends shall be threaded. A PVC-coated threaded coupling shall be furnished with each length of conduit. A PVC sleeve equal to the OD of the conduit shall extend 2 inches from each end of the coupling.

3. Factory threaded ends shall be provided a urethane coating. Field cut threads shall be coated as specified in Part 3 herein.

4. Conduit, couplings, elbows, bends, nipples, and connectors shall be as manufactured by Ocal, Perma-Cote, or equal.

E. Rigid Stainless Steel (RSS) Conduit

1. RSS conduit, couplings, elbows, bends, and nipples shall be in accordance with ANSI C80.1 and UL 6A, and shall be constructed of Type 304 stainless steel.

2. RSS conduit ends shall be threaded. A threaded coupling shall be furnished with each length of conduit. Color-coded end caps shall be provided to protect conduit threads. Thread-less fittings are not acceptable.

3. All conduit cut ends shall be reamed or otherwise finished to remove rough edges. Where conduit is threaded in the field, a standard cutting die with tapered threads (3/4-in. taper per foot) shall be used. Running threads are not acceptable.
4. Conduit, couplings, elbows, bends, and nipples shall be as manufactured by Allied Tube & Conduit, Conduit Pipe Products Company, or equal.

2.06 NONMETALLIC CONDUITS

A. Nonmetallic conduit, elbows, and couplings shall be constructed of high impact, extruded, rigid polyvinyl chloride (PVC) resin. Nonmetallic conduit and fittings shall be heavy wall, Rigid Schedule 40 or Schedule 80 PVC, and rated of 90 degree C conductors. Conduit shall conform to UL 651, and NEMA TC-2, and shall be listed for underground applications encased in concrete or direct bury. PVC material shall be sunlight resistant.

B. PVC conduit shall be manufactured with integral bell ends for solvent cement welding. Each length of conduit shall bear the manufacturer’s name and UL label. Minimum conduit size shall be 3/4", unless noted otherwise.

C. Conduit fittings shall conform to NEMA TC-3, and shall be of the same material and strength characteristics as the conduit. Unless specified otherwise, elbows shall be long radius sweeps meeting the requirements of the NEC. Conduit fittings shall be provided with plain ends or bell ends for solvent cement welding.

D. Conduit, elbows, and couplings shall be as manufactured by Carlon, JM Eagle, or equal.

2.07 LIQUID-TIGHT FLEXIBLE METAL CONDUITS

A. Liquid-tight flexible metal conduit shall be in accordance with UL 360 and NEC Article 350. Liquid-tight flexible metal conduit shall be constructed of continuously interlocked hot dipped zinc galvanized steel core covered by a sunlight resistant and flame retardant thermoplastic gray PVC jacket that resists heat, oil, and chemical breakdown. Liquid-tight flexible metal conduit shall be approved for both exposed and concealed locations, and shall be rated for temperature ranges of -4 to 140 °F.

B. Conduits, 1-1/4 inch and smaller, shall have an internal copper bonding conductor wound spirally in the space between each convolution.

C. Unjacketed or non-metallic flexible conduit is not acceptable.

D. Liquid-tight flexible metal conduit shall be as manufactured by Anaconda, Electri-Flex, or equal.

2.08 CONDUIT FITTINGS

Conduit fittings shall include hub, liquid-tight connectors, unions, reducers, and plugs as specified herein.
A. Materials

1. Conduit fittings shall be constructed of malleable iron, aluminum, or stainless steel. Materials provided shall be consistent with the conduit material being used (i.e. malleable iron with RSG conduit, aluminum with RA conduit, and stainless steel with RSS conduit).

2. Where PVC coated conduit systems are specified, all conduit fittings shall be PVC coated.

B. Hubs for Rigid Metal Conduits

1. Threaded conduit hubs shall be provided for all conduit connections to enclosures without integral hubs. Each hub shall be furnished with a captive o-ring gasket, insulated throat, and vibration-proof nut equipped with a grounding screw. Machined serrations on hub and nut shall bite into the enclosure assuring a tight, vibration-proof connection.

2. Hubs shall be rated NEMA Type 2, 3, 3R, 4, 4X and 12. Hubs shall be certified for NEC, Class I, Division 2, and Class II, Divisions 1 and 2 hazardous locations.

3. Hubs shall be Crouse-Hinds Types STG, STAG, SSTG, or equal.

C. Connectors for Liquid-Tight Flexible Metal Conduits

1. Connector bodies shall be straight, 45° angle, and 90° angle, as required for the installation conditions. Each connector shall be furnished with an insulated throat, gland nut, ferrule, gland nut sealing ring, sealing gasket and locknut. Connectors shall seal out water, oil, dust, and dirt.

2. Connectors shall be certified for NEC, Class I, Division 2, and Class II, Divisions 1 and 2 hazardous locations.

3. Connectors shall be Crouse-Hinds Types LTB, LT-SA, or equal.

D. Unions

1. Union shall be provided, as required, for conduit connections to threaded outlet bodies, boxes, and equipment, and for connecting two rigid conduits together. Unions shall be male, female, or male and female depending upon application.

2. Unions shall be constructed of cast gray iron, or copper-free aluminum, consistent with conduit material being used.
3. Unions constructed of gray iron shall have finish of zinc plating and aluminum acrylic paint. Unions constructed of copper-free aluminum shall be protected with an epoxy powder coat finish.

4. Unions shall be Crouse Hinds UNY, UNF, UNL, UNA, or equal.

E. Reducers and Plugs

1. Reducers shall be used to reduce conduit hubs to the next smaller size and to connect to different sizes of threaded conduit. Plugs shall be used to close threaded conduit hubs.

2. Reducers shall be constructed of machined steel, cast gray iron, or cast malleable iron. Plugs shall be constructed of machined steel, cast gray iron, or copper-free aluminum, consistent with conduit material being used.

3. Reducers and plugs shall have external NPT tapered threads with a minimum of five threads.

4. Reducers and plugs constructed of ferrous metal shall have a finish of zinc plating with aluminum acrylic paint. Plugs constructed of copper-free aluminum shall be protected with an epoxy powder coat finish.

5. Reducers and plugs shall be Crouse Hinds RE, REC, PLG, or equal.

2.09 CONDUIT OUTLET BODIES AND OUTLET BOXES

A. Conduit outlet bodies and outlet boxes shall be in accordance with UL 514A, UL 514B, and Fed Spec W-C-586. Conduit outlet bodies and outlet boxes shall be constructed for applications in accordance with the National Electrical Code Article 314.
B. Conduit outlet bodies shall be furnished in conduit systems to: connect conduit sections, make 90° bends in conduit runs, provide pull outlets when conductors are being installed, and provide openings for making splices in conductors. Conduit outlet boxes shall be furnished in conduit systems to: act as junction boxes, act as pull outlets, accept round base wiring devices and covers, and mount lighting fixtures.

C. Conduit bodies and boxes shall be provided with threaded hubs and tapered NPT threads. Conduit bodies and boxes shall have an integral bushing to protect wire insulation. Conduit bodies shall be provided with an internal PTFE coating for easier wire pulling. Conduit bodies and boxes shall be provided with covers and neoprene gaskets and shall be weather-proof.

D. Conduit bodies and boxes shall be constructed of gray iron, copper-free aluminum, or stainless steel, consistent with the conduit material being used, unless indicated otherwise on the Drawings. Covers for conduit bodies and boxes shall be constructed of the same material as the main body.

E. Conduit bodies and boxes constructed of gray iron shall be protected with a finish of zinc plating and epoxy powder coating. Conduit bodies constructed of copper-free aluminum shall be protected with an epoxy powder coat finish.

F. Where conduit bodies and boxes are connected to PVC-coated conduit, bodies shall receive the same preparation and PVC-coating as the conduit.

G. Conduit bodies and boxes constructed of stainless steel shall be made from Type 316 stainless steel investment casting. Covers shall be stamped from Type 316 stainless steel. Screws and sealing washers shall be constructed of Type 18-8 stainless steel. Gaskets and retainers shall be constructed of neoprene rubber. Stainless steel conduit bodies shall be approved for use in wet locations.

H. Conduit outlet bodies shall be Form 7 or Form 8, as manufactured by Crouse-Hinds, or equal. Conduit outlet boxes shall be Crouse-Hinds GRFX or VXF, or equal.

2.10 EXPLOSION-PROOF CONDUIT COMPONENTS

A. General

1. All conduit outlet bodies, boxes, sealing fittings, flexible couplings, elbows, reducers, plugs, and unions provided for use in hazardous locations as defined in the NEC, shall be explosion-proof and dust ignition-proof.

2. All products shall be approved for use in Class I, Divisions 1 and 2, Groups A, B, C, and D, and Class II, Divisions 1 and 2, Groups E, F, and G locations.
3. Explosion-proof products shall be UL Listed to UL 886.

4. Explosion-proof products used in outdoor or wet locations, shall be rain-tight and water-tight.

5. Where explosion-proof products are connected to PVC-coated conduit or used in a PVC-coated conduit system, products shall receive the same preparation and PVC-coating as the conduit.

B. Conduit Outlet Bodies and Outlet Boxes

1. Conduit outlet bodies and outlet boxes shall be used for pulling wire, changing direction of conduit, providing access for splicing wires and maintenance, and interconnecting lengths of threaded conduit.

2. Conduit outlet bodies and outlet boxes shall be constructed of gray iron or copper-free aluminum, consistent with the conduit material being used, unless indicated otherwise on the Drawings.

3. Conduit bodies and boxes shall be provided with threaded hubs and tapered NPT threads. Conduit bodies and boxes shall have an integral stop bushing to protect wire insulation and shall be provided with an internal PTFE coating for easier wire pulling. Conduit bodies and boxes shall be provided with covers and neoprene gaskets. Conduit boxes shall be provided with screw on covers for easy access.

4. Gray iron conduit bodies and boxes shall be provided with covers constructed of gray iron. Conduit bodies, boxes, and covers constructed of gray iron shall be protected with a finish of zinc plating and epoxy powder coating.

5. Conduit bodies and boxes constructed of copper-free aluminum shall be protected with an epoxy powder coat finish.

6. Conduit outlet bodies and outlet boxes shall be Crouse Hinds LBH, LBY, EKC, GUA, EAB, EAJ, GUJU, and OE, or equal.

C. Sealing Fittings

1. Sealing fittings shall be provided to restrict the passage of gases, vapors, or flames from one electrical installation to another through the conduit system.
2. Sealing fittings and plugs shall be constructed of gray iron or copper-free aluminum, consistent with the conduit material being used, unless indicated otherwise on the Drawings. Sealing fittings shall be weatherproof and suitable for outdoor exposure.

3. Sealing fittings and plugs constructed of gray iron shall be protected with a finish of zinc plating and epoxy powder coating or aluminum acrylic coating. Sealing fittings and plugs constructed of copper-free aluminum shall be protected with an epoxy powder coat finish.

4. Sealing compound shall be installed in all seal fittings and shall be UL listed, non-shrinking, and resistant to water, oil, and acids. Packing fiber shall be installed to form a positive dam to hold the sealing compound. Packing fiber shall be made from non-asbestos material. Sealing compound and packing fiber shall be provided by the same manufacturer as the sealing fittings.

5. Conduit sealing fittings shall be suitable for installation in the vertical and horizontal position. Conduit sealing fittings shall be Crouse-Hinds EYS, EZS, or equal.

D. Flexible Couplings

1. Flexible couplings shall be used to connect conduit to stationary equipment that vibrates or moves due to changes in temperature or pressure, and to achieve tight bends.

2. Flexible couplings shall have a flexible inner core and outer braided covering attached to NPT tapered threaded fittings. Flexible inner core, outer braided covering and end fittings shall be constructed of stainless steel. The metallic braid and fittings shall be provided completely factory assembled.

3. For severely corrosive locations, couplings shall be furnished with a flexible PVC protective coating.

4. Flexible couplings shall be Crouse-Hinds ECGJH, ECLK, or equal.

E. Elbows, Reducers, Plugs, and Unions

1. Elbows, reducers, plugs, and unions shall be constructed of machined steel, cast gray iron or copper-free aluminum, consistent with the conduit material being used, unless indicated otherwise on the Drawings.
2. Elbows shall be threaded and shall be used to change direction of conduit by 45° or 90°, or when terminating at a box or fitting. Elbows shall be male, female, or male and female depending upon application.

3. Reducers shall be used to reduce conduit hubs to the next smaller size and to connect to different sizes of threaded conduit. Plugs shall be used to close threaded conduit hubs. Reducers and plugs shall have external NPT tapered threads with a minimum of five threads.

4. Unions (three-piece couplings) shall be provided, as required, for conduit connections to threaded outlet bodies, boxes, and equipment, and for connecting two steel conduits together. Unions shall be male, female, or male and female depending upon application.

5. Elbows, plugs, and unions shall be constructed of machined steel, cast gray iron, or copper-free aluminum, consistent with conduit material being used, unless indicated otherwise on the Drawings. Reducers shall be constructed of machined steel, cast gray iron, or cast malleable iron.

6. Elbows, reducers, plugs, and unions constructed ferrous metal shall have finish of zinc plating and epoxy powder coating or aluminum acrylic coating. Elbows, reducers, plugs, and unions constructed of copper-free aluminum shall be protected with an epoxy powder coat finish.

7. Elbows, reducers, plugs, and unions shall be Crouse Hinds EL, RE, REC, REA, PLG, UNY, UNF, UNL, or equal.

2.11 DEVICE BOXES AND COVER PLATES

A. General Purpose Device Boxes - Indoors or Outdoors

1. Device boxes shall be in accordance with UL 514 and ANSI C33.84, and shall be constructed of cast gray iron or copper-free aluminum, consistent with the conduit material being used, unless indicated otherwise on the Drawings. Device boxes shall be weatherproof and suitable for outdoor exposure.

2. Device boxes shall be deep-type, minimum single gang size with threaded hubs, internal ground screw, and neoprene gasket for device cover plate. Device boxes shall be properly sized for the required devices or splicing. Surface mounted boxes shall be provided with integral mounting lugs.
3. Gray iron device boxes shall be provided with a hot dipped galvanized finish. Aluminum device boxes shall be provided with an epoxy powder coat finish (internal and external). Where device boxes are connected to PVC-coated conduit, boxes shall receive the same preparation and PVC-coating as the conduit.

4. Device boxes shall be Crouse-Hinds FD, Appleton FD, or equal.

B. **Type 316 Stainless Steel Device Boxes**

Where indicated on the Drawings, device boxes shall be constructed of Type 316 stainless steel, minimum single gang size, deep-type, with gasket and Type 316 stainless steel solid cover. Device boxes shall be properly sized for required circuitry or splicing. Surface mounted boxes shall be furnished with mounting lugs or feet. Device boxes shall be NEMA Type 4X, UL listed, and as manufactured by Wiegmann, or equal.

C. **Pressed Steel Device Boxes**

Device boxes may be constructed of pressed steel in lieu of cast gray iron or aluminum boxes where device boxes are required to be concealed, as indicated on the Drawings. Concealed device boxes shall be recessed in masonry or concrete walls, steel or wood stud walls, and concrete ceilings. Pressed steel device boxes shall be constructed of pre-galvanized steel, 0.062" minimum thickness. Metallic brackets shall be pre-galvanized steel or zinc plated cold roll spring steel. Pressed steel device boxes shall be provided with standard trade size knockouts to support attachment of conduit. Boxes shall be provided with a tapped hole at the bottom for attaching a ground screw. Boxes shall be deep-type and furnished with extensions as necessary for flush mounting of cover plates with the finished wall or ceiling surface. Pressed steel device boxes shall be UL listed, and as manufactured by Thomas & Betts, or equal.

D. **Cover Plates**

Unless indicated otherwise on the Drawings, cover plates for device boxes shall be as specified herein. Cover plates for device boxes containing toggle switches or receptacles shall be configured to match the mounted device. Cover plates for device boxes containing wiring splices shall be solid.

1. **General Purpose - Indoors**

Cover plates shall be stainless steel Type 302/304, standard size, smooth finish without grain, and be attached with slotted stainless steel screws. Stainless steel cover plates shall be manufactured by Hubbell, Cooper, or equal.
2. **Damp Locations**

Cover plates installed in damp locations shall be gasketed cast metal (matching the device box), self-closing, weatherproof cover plates. Weatherproof cover plates shall be manufactured by Hubbell, Cooper, or equal.

3. **Outdoor and Wet Locations**

Cover plates installed in outdoor and wet locations shall be gasketed cast aluminum, weatherproof, extra duty rated, in use type cover plates. Weatherproof extra duty in use cover plates shall be manufactured by Legrand, Thomas & Betts, or equal.

4. **PVC Coating Conduit Systems**

Unless indicated otherwise on the Drawings, cover plates installed in PVC coated conduit systems shall be gasketed, cast metal, PVC coated and be manufactured by the same manufacturer as the PVC coated conduit. PVC coated cover plates shall be manufactured by Ocal, Perma-Cote, or equal.

### 2.12 JUNCTION BOXES

**A. General Purpose - Indoors or Outdoors**

1. Unless indicated otherwise on the Drawings, junction boxes shall be rated NEMA 4 where located indoors or outdoors. NEMA 3R junction boxes are not acceptable.

2. Junction boxes shall be properly sized for the number and sizes of conductors and conduit entering the box and required splicing or termination. Junction boxes shall be a minimum size of 4" x 4" x 3".

3. NEMA 4 junction boxes shall be constructed of gray iron or sheet metal. PVC junction boxes are not acceptable.

4. Gray iron junction boxes shall be provided with gasketed screw-on covers and shall be hot dipped galvanized. Junction boxes shall be provided with feet where necessary for surface mounting. Gray iron junction boxes shall be Crouse-Hinds WAB, Appleton RS, or equal.
5. Sheet metal junction boxes shall be constructed of 14 gauge minimum sheet steel and shall be galvanized after fabrication and provided with a wash and phosphate undercoat, and ANSI 61 gray acrylic electrocoat finish. Sheet metal junction boxes shall be provided with tabs where necessary for surface mounting. Sheet metal junction boxes shall be provided with gasketed, continuous hinged solid doors and padlockable door hasps. Sheet metal junction boxes shall be as manufactured by Hoffman, Wiegmann, Cooper B-Line, or equal.

B. Wet or Corrosive Locations

1. Unless indicated otherwise on the Drawings, junction boxes shall be rated NEMA 4X where located in wet or corrosive locations. Junction boxes shall be properly sized for the number and sizes of conductors and conduit entering the box and required splicing or termination. Junction boxes shall be a minimum size of 4" x 4" x 3".

2. NEMA 4X junction boxes shall be constructed of Type 316 stainless steel, and provided with gasketed, continuous hinged solid doors and padlockable door hasps. PVC junction boxes are not acceptable.

3. NEMA 4X junction boxes shall be manufactured by Hoffman, Wiegmann, or equal.

2.13 METAL WIREWAYS

A. General

1. Metal wireways shall be UL listed, with NEMA ratings and sizes as indicated on the Drawings, and shall conform to the requirements specified herein.

2. Metal wireways straight sections shall be 4" wide x 4" high (minimum).

3. Wireway fittings and accessories shall conform to straight section width and height.

4. Direction and size changes shall be completed through the use of pre-fabricated fittings provided by the wireway manufacturer.

5. Metal wireways shall be manufactured by Hoffman, Cooper B-Line, or equal.

B. Indoor Locations

1. Unless indicated otherwise on the Drawings, wireways shall be rated NEMA 12 where located indoors.
2. NEMA 12 wireways shall be "lay-in" type and shall be provided with bodies and covers fabricated from 14 gauge galvannealed steel. Flanges shall be constructed of 10 gauge galvannealed steel. Covers shall be secured to the wireway and fitting body with heavy duty butt hinges and quick release latches. Covers and flanges shall be provided with oil-resistant gaskets. All covers and sealing plates shall be hinged completely open or removed to allow for continuous "lay-in" cable feed.

3. NEMA 12 wireway systems shall be provided with a wash and phosphate undercoat, and an ANSI 61 gray polyester powder finish.

C. Outdoor or Corrosive Locations

1. Unless indicated otherwise on the Drawings, wireways shall be rated NEMA 4X where located outdoors or in corrosive areas.

2. NEMA 4X wireways shall be "feed-through" type and shall be provided with bodies and covers fabricated from 14 gauge Type 304 stainless steel. Flanges shall be constructed of 10 gauge stainless steel. Covers shall be secured to the wireway body with heavy duty hinges on one side and screw clamps mounted on the opposite side. Covers and flanges shall be provided with oil-resistant gaskets. Outer surface of wireway body, cover, and fittings shall be provided with a smooth brushed finish.

2.14 NON-METALLIC WIREWAY

A. General

1. Non-metallic wireway shall be solid bottom type construction with minimum wall thickness of 0.1875". Covers and cover splice plates shall be snap-on type construction requiring no installation fasteners.

2. The wireway system shall conform to the applicable sections of NEC Article 362.

3. The non-metallic wireway system shall be as manufactured by Enduro Composite Systems, Inc., or equal.

B. Construction

1. Wireways, covers, and connector plates shall be pultruded utilizing polyester resin with UV light inhibiting additives and exterior nexus veil coverage.

2. All composite material shall meet ASTM E84, maximum 25 flame spread rating.

3. All cut ends and drilled holes (factory and field) shall be sealed with resin coating.
C. Connections, Accessories, and Supports

1. Connector plates shall be fiberglass and designed to transfer wireway loads to the support system. Fasteners for connector plates shall be Type 316 stainless steel or FRP studs and hex nuts as required.

2. Wireways shall be provided with fiberglass flat snap-on/snap-off covers.

3. Wireway support systems shall be constructed of polyester or vinyl ester resin strut channels (single or double channel as necessary) and appurtenances. Support spacing shall be in accordance with the wireway manufacturer’s printed recommendations for the specified loads.

2.15 METAL CABLE TRAY

A. Metal cable tray shall be constructed of aluminum, and shall be ladder type or ventilated trough type, as specified herein. Cable tray shall be provided with all splice plates, bolts, nuts and washers for connecting tray units. Units shall be constructed with rounded edges and smooth surfaces; in compliance with NEMA VE-1.

Cable tray shall be sized by the Contractor to support all the conductors and cables shown on the Drawings plus an additional 20% spare capacity for future use, when supported as a simple span of a maximum of 10 feet. In addition to the conductor and cable load, the cable tray shall support a 200 lb. concentrated load at mid-point of span and centerline of tray.

B. Metal cable tray straight section and fitting side rails and rungs shall be extruded from aluminum alloy 6063. All fabricated parts shall be constructed from aluminum alloy 5052.

C. 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. Spacing in radiused fittings shall be 9 inches and measured at the center of the tray's width. Rungs shall have a minimum cable-bearing surface of 7/8 inch with radiused edges. No portion of the rungs shall protrude below the bottom plane of the side rails.

D. Ventilated trough type trays shall consist of two longitudinal members (side rails) with a corrugated bottom welded to the side rails. The peaks of the corrugated bottom shall have a minimum flat cable-bearing surface of 2-3/4 inches and shall be spaced 6 inches on center. To provide ventilation in the tray, the valleys of the corrugated bottom shall have 2-1/4 inch by 4 inch rectangular holes punched along the width of the bottom.
E. Trays shall have 4 inch minimum usable load depth, unless indicated otherwise on the Drawings.

F. Straight tray sections shall have side rails fabricated as I-Beams. All straight sections shall be supplied in standard 12 or 24 foot lengths, except where shorter lengths are required to facilitate tray assembly as shown on the Drawings.

G. Tray widths shall be 18 inches, unless indicated otherwise on the Drawings.

H. All fittings shall have a minimum radius of 12 inches.

I. Splice plates shall be the bolted type made of 6063-T6 aluminum, using four square neck carriage bolts and serrated flange locknuts. Hardware shall be zinc plated in accordance with ASTM B633, SC1. Hardware shall be Type 316 stainless for aluminum cable tray installed outdoors. Splice plate construction shall be such that a splice may be located anywhere within the support span without diminishing rated loading capacity of the cable tray.

J. Separate cable tray systems shall be provided for power cables, and for instrumentation cables. Power cable trays shall include conductors for 480 V, 240 V, and 120 V power circuits, and shall be located above instrumentation cable trays, unless indicated otherwise on the Drawings. Instrumentation cable trays shall include cables for instrumentation, signal, communication, and control circuits. Metal barriers shall be installed in instrumentation cable trays to provide separation of analog signals and communication circuits from digital circuits. In addition, metal barriers shall be installed in power cable trays to provide separation of variable frequency drive (VFD) motor circuits from all other power circuits.

K. Cable tray supports shall be located so that the support spans do not exceed maximum span specified herein, or shown on the Drawings. Supports shall be constructed from 12 gauge steel strut channel (1-5/8 inch by 1-5/8 inch, minimum) with all necessary hardware such as Trapeze Support Kits (9G-55XX-22SH) as manufactured by Cooper B-Line, or equal. Cable trays installed adjacent to walls shall be supported on wall mounted brackets such as B409 as manufactured by Cooper B-Line, or equal.

L. Trapeze hangers and center-hung supports shall be supported by 1/2 inch (minimum) diameter rods.

M. Barrier strips shall be placed as specified herein, and shall be fastened into the tray with self-drilling screws.

N. Special accessories shall be furnished as required to protect, support, and install a cable tray system. Accessories shall consist of but are not limited to; section splice plates, expansion plates, blind-end plates, specially designed ladder dropouts, barriers, etc.
O. Where cable tray penetrates wall, the penetrations shall be fire-stopped using plates on both sides of the penetration and filling the void in between with UL approved silicone foam as required to provide a 2-hour (minimum) fire rating.

P. All conductors and cables installed in cable trays shall be tray-rated cable types. Conduits used between equipment and cable tray shall be sized to meet NEC requirements based on the diameters of the tray-rated cables.

Q. Cable tray systems shall be as manufactured by Cooper B-Line, or equal.

2.16 NON-METALLIC CABLE TRAY

A. Non-metallic cable tray shall be constructed of glass fiber reinforced polyester or vinyl ester resin, and shall be solid bottom type or ventilated trough type, as specified herein. Cable tray shall be provided with all splice plates, bolts nuts and washers for connecting tray units. Units shall be constructed with rounded edges and smooth surfaces; in compliance with NEMA FG-1.

Cable tray shall be sized by the Contractor to support all the conductors and cables shown on the Drawings plus an additional 20% spare capacity for future use, when supported as a simple span of a maximum of 10 feet, while maintaining a minimum safety factor of 1.5.

B. Straight section structural elements; side rails, rungs and splice plates shall be pultruded from glass fiber reinforced polyester or vinyl ester resin. Pultruded shapes shall be constructed with a surface veil to insure a resin-rich surface and ultraviolet resistance. Pultruded shapes shall meet ASTM E-84, Class 1 flame rating and self-extinguishing requirements of ASTM D-635.

C. Ventilated bottom cable trays shall consist of two longitudinal members (side rails) with rungs spaced 4" on center.

D. Solid bottom cable trays shall consist of two longitudinal members (side rails) with a solid sheet over rungs spaced on 12" centers.

E. Cable tray loading depth shall be 3 inches per NEMA FG-1, unless indicated otherwise on the Drawings.

F. Straight sections shall be supplied in standard 10 foot or 20 foot lengths.

G. Cable tray inside widths shall be 18 inches, unless indicated otherwise on the Drawings. Outside width shall not exceed inside by more than a total of 2".

H. Straight and expansion splice plates will be of "L" shaped lay-in design. Splice plates shall be furnished with straight sections and fittings.
I. All fittings must have a minimum radius of 12.

J. Molded fittings shall be formed with a minimum 3" tangent following the radius.

K. Systems with 3 inch loading depth shall have 90° and 45° molded fittings in 12 inch or 24 inch radius. Systems with 5 inch loading depth shall have 90° and 45° molded fittings in 24 inch or 36 inch radius. All other fittings shall be of mitered construction.

L. Unless indicated otherwise on the Drawings, cable trays shall be provided with fiberglass flat covers.

M. Cable tray support systems shall be constructed of polyester or vinyl ester resin strut channels (single or double channel as necessary) and appurtenances. Support spacing shall be in accordance with the cable tray manufacturer's printed recommendations for the specified loads.

Cable tray manufacturer shall provide all clamps, support assemblies, and appurtenances necessary for the installation of a complete cable tray system.

N. All conductors and cables installed in cable trays shall be tray-rated cable types. Conduits used between equipment and cable tray shall be sized to meet NEC requirements based on the diameters of the tray-rated cables.

O. Cable tray systems shall be as manufactured by Cooper B-Line, or equal.

2.17 RECEPTACLES AND SWITCHES

Receptacles and switches shall be specification grade, heavy duty and provided in cast metal boxes with gasketed covers as identified and located on the Drawings. Unless otherwise indicated, the device phenolic color shall be ivory for all receptacles and toggle switches.

A. General Purpose Convenience Receptacles

General purpose convenience receptacles shall be duplex, 3-wire grounding type, weather resistant, rated 125 /250 volt, AC, rated 20 amp minimum, NEMA 5-20R, and equipped with double sided screw terminals for copper wire. Convenience receptacles shall be as manufactured by Hubbell, Pass & Seymour, or equal.

B. Ground Fault Interrupter (GFI) Receptacles

GFI receptacles shall be duplex, weather resistant, NEMA 5-20R configured, ivory in color, and shall mount in a standard device box. Units shall trip at 5 mA of ground current and shall comply with NEMA WD-1-1.10 and UL 943. GFI receptacles shall be capable of
individual protection as well as downstream protection, as manufactured by Hubbell, Pass & Seymour, or equal.

C. **Toggle Switches**

Local single pole switches shall be flush tumbler type AC rated, quiet type, heavy duty, rated 20 amp minimum, rated 120/277 volt, equipped with side screw terminals for copper wire. Switches shall conform to NEMA WD-1 Specifications. Two pole, three-way and other switches shall be similar. Switches shall be as manufactured by Hubbell, Pass & Seymour, or equal.

### 2.18 PILOT DEVICES AND LOCAL CONTROL STATIONS

A. **Pilot Devices**

1. Pilot devices consisting of oiltight/watertight push buttons, selector switches, pilot lights, and incidental items shall be as manufactured by Allen-Bradley, Eaton/Cutler Hammer, or Schneider/Square D (no substitutes).

2. Pilot devices shall be heavy duty, suitable for mounting in control stations or on control panels, and other electrical equipment.

   a. Pilot devices shall be 30.5 mm, NEMA Type 4/13 with cast metal bases, chrome-plated octagonal mounting nuts, and legend plates.

   b. Push buttons and switch knobs shall be heavy duty plastic. Pilot light lenses shall be shatter resistant plastic. Lens color shall be as indicated on the Drawings.

   c. Contact blocks shall have AC contact ratings of NEMA A600, 10 A with silver contacts for corrosion resistance and clear side plates for contact inspection.

   d. Pilot light devices shall be push-to-test type and shall be provided with LEDs and transformers suitable for operation on 120 VAC power.

B. **Local Control Stations**

1. Local control stations shall consist of various pilot devices mounted in a device box and located as shown on the Drawings. Pilot devices and control wiring shall be as indicated on the Drawings. Pilot devices (e.g. selector switches, pilot lights, and push buttons) shall be in accordance with the requirements specified herein.
2. Local control station device boxes shall be as specified herein and shall have the following NEMA ratings, unless indicated otherwise on the Drawings:

a. Non-Hazardous Indoor Locations NEMA 12
b. Hazardous Indoor Locations NEMA 7
c. Outdoor Locations NEMA 4X
d. Hazardous Outdoor Locations NEMA 4 and NEMA 7

Local control station enclosures shall be of adequate size to contain the specified pilot devices, wiring, and components.

3. Local control stations shall be provided with nameplates inscribed with the name of the equipment being controlled and the control station name (e.g. Pump No. 1, Lock-Out-Stop). In addition, each pilot device shall be provided with an integral legend plate, inscribed with the function of the respective pilot device.

4. Mechanical "Lock-Out-Stop" devices where installed on pilot device "Stop" push buttons shall be constructed of stainless steel, and shall be suitable for padlocking in the "Stop" position. Mechanical "Lock-Out-Stop" devices shall be manufactured by the same manufacturer as the push button.

2.19 PANELBOARDS

Panelboards shall be factory assembled, metal enclosed, gasketed, bolted dead front and equipped with thermal-magnetic molded case circuit breakers as shown on the Drawings and as specified in Specification Section 16480, Motor Control Centers, Switchboards, and Panelboards.

2.20 OVERCURRENT PROTECTION

Circuit breakers, fuses, relays and other protective devices that protect conductors and equipment against overload currents and short circuit currents shall be provided as indicated, specified and required. Overcurrent protection devices are specified in Specification Section 16480, Motor Control Centers, Switchboards, and Panelboards.
2.21 DISCONNECT SWITCHES

Provide fusible disconnect switches, or non-fusible disconnect switches, as indicated on the Drawings and as specified herein.

A. Switches shall be steel enclosed, heavy duty, 2-pole 250 VAC or 3-pole 600 VAC, fusible or non-fusible, as indicated on the Drawings and specified herein. Disconnect switches shall be UL listed and conform to NEMA KS1. Disconnect switches shall be as manufactured by Eaton/Cutler-Hammer, Schneider/Square D, or equal.

B. The operating mechanism shall be spring driven, with quick-make, quick-break action. Switch contact shall be knife-blade and jaw construction, with visible blades.

C. Operating handles shall be flange mounted as an integral part of the operating mechanism. The operating handle shall clearly indicate the "On" and "Off" position, and shall have provisions for padlocking with up to three (3) 3/8 inch padlocks.

D. Switches shall incorporate safety cover interlocks to prevent opening the hinged cover with the switch in the "On" position or prevent closing the switch mechanism and placing the switch in the "On" position with the hinged cover open. Provide a defeater for authorized personnel.

E. Each switch shall be provided with a factory installed equipment grounding kit and fuse puller kit.

F. Switches shall be provided with metal enclosures having the following NEMA ratings, unless indicated otherwise on the Drawings

1. Non-hazardous Indoor Locations NEMA 12
2. Hazardous Indoor Locations NEMA 7
3. Outdoor Locations NEMA 4X (Type 316 stainless steel)
4. Hazardous Outdoor Locations NEMA 4 and NEMA 7

G. Non-fusible switches shall have a minimum short circuit current rating of 10,000 A, when used in conjunction with a circuit breaker of any brand.
H. Fusible switch units shall be equipped with all required mounting brackets and guides. Unless specified otherwise, fusible switches with 30 A through 600 A frames shall be provided with rejection Class "R" type fuse clips. Unless specified otherwise, fusible switches with 800 A through 1200 A frames shall be provided with Class L type fuse clips. Fusible switches and fuses shall have a minimum short circuit current rating of 200,000 A. All fuses shall be provided by the manufacturer. Contractor shall confirm fuse type. Contractor shall coordinate with manufacturer, including supplying manufacturer with data on actual equipment to be furnished and results of short circuit coordination study.

I. Switches shall be provided with a phenolic nameplate on the hinged cover that identifies the load.

2.22 SUPPORTS

Contractor shall provide strut channels, fittings, stanchions, clamps, hangers, and required hardware to support all conduit and equipment, as shown on the Drawings and specified herein, and as required. Refer also to earthquake restraint provisions of Section 11005.

A. Strut Channel Supports

1. Unless indicated otherwise on the Drawings, strut channel shall be single strut type, 1-5/8" x 1-5/8", 12 gauge hot dipped galvanized steel with 9/16" diameter bolt holes on 1-7/8" centers.

2. Where indicated on the Drawings, strut channel shall be single strut type, 1-5/8" x 1-5/8", heavy duty, fiberglass (vinylester) with 1" x 7/16" bolt holes on 2" centers.

3. Where indicated on the Drawings, strut channel shall be single strut type, 1-5/8" x 1-5/8", Type 304 stainless steel with 9/16" bolt holes on 1-7/8" centers.

4. Where indicated on the Drawings, strut channel shall be single strut type, 1-5/8" x 1-5/8", 12 gauge, PVC coated pre-galvanized steel, with 9/16" bolt holes on 1-7/8" centers. PVC coating shall be as specified herein for PVC coat rigid metal conduit.

5. Deep strut or double strut channel shall be provided where required for the support load or configuration.

6. Strut channel supports shall be furnished with all fittings required for a particular support configuration, including: conduit clamps, flat plate fittings, angle fittings, 90° fittings, brace fittings, zee fittings, "U" fittings, wing fittings, and post bases.
7. Strut channel fittings and fasteners shall be fabricated from the same material and receive the same coating, as specified for the strut channel.

8. Strut channels, fittings, and fasteners shall be as manufactured by Power-Strut, Unistrut, or equal.

B. One-Hole Clamps

Clamps shall be malleable iron, hot dipped galvanized, and equipped with clamp-backs. Clamps shall be as manufactured by Crouse-Hinds, Thomas & Betts, Appleton, or equal.

C. Beam Clamps

Clamps shall be malleable iron, hot dipped galvanized, right angle and parallel types. Clamps shall be as manufactured by Crouse-Hinds, Thomas & Betts, Appleton, or equal.

D. U-Bolts

U-bolts shall be heavy-duty steel, electro-galvanized and equipped with two hex steel nuts. U-bolts shall be as manufactured Crouse-Hinds, Efcor, Kindorf, or equal.

E. Conduit Hangers

Conduit hangers shall be heavy gauge formed steel, galvanized and equipped with carriage bolts, 1/4-inch (minimum) rods and nuts. Conduit hangers shall be as manufactured by Kindorf, Appleton, or equal.

F. Lighting Fixture Hangers

Fixture hangers shall be cast iron alloy, cushion type, and equipped with outlet body and cover for fixture wiring. Fixture hanger shall permit the fixture to swing 20º from perpendicular in any direction. Fixture hangers shall be Crouse-Hinds Type ALT, Appleton Type ALT, or equal.

G. Fasteners and Anchors

1. Fasteners and anchors shall be provided to securely mount all equipment and materials.

2. Unless specified otherwise, all fasteners and anchors shall be constructed of Type 304 stainless steel.
3. Stainless steel anchors shall be provided for securing equipment and supports to masonry and concrete walls, concrete foundations, and concrete floors. Stainless steel anchors shall be wedge anchors, sleeve anchors, or epoxy anchors, as manufactured by Red Head, Hilti, or equal.

H. Spacers

Spacers shall be provided to support underground conduits for concrete encasements. Spacers shall be modular, interlocking, and constructed of high impact plastic with sufficient strength to support multiple layers of conduit. Spacers shall be as manufactured by Carlon, JM Eagle, or equal.

2.23 GROUNDING

A. Grounding and grounding components shall comply with the applicable requirements of the NEC, Article 250.

B. Grounding conductors shall be stranded copper and shall be sized in accordance with NEC requirements when sizes are not indicated on the Drawings.

C. Grounding rods shall conform to ANSI/UL 467 and shall be copper-clad steel, 3/4” (minimum) in diameter and 10’ (minimum) in length. Rods shall be driven in the ground at least 9′-6″ deep.

Provide the number of rods required to obtain proper ground resistance, as applicable to all service entrances, transformers, building/structure ground rings, manholes, pull boxes, etc.

D. All grounding connections of copper to copper and copper to steel of #8 AWG and larger sized conductors shall be exothermic welded connections (Cadweld). Exothermic welded connections shall create a non-removable fusion of copper grounding conductors and high conductivity copper content alloy connecting sleeves. Exothermic welding systems shall be manufactured by Erico, Furseweld, or equal.

E. All grounding connections to equipment shall use bolted lugs. When the conductor is #8 AWG and larger, the lug shall be joined to the conductor by the Cadweld exothermic weld process.
When the conductor is smaller than #8 AWG, the lug shall be joined by compression connectors manufactured from pure wrought copper. The connectors shall meet or exceed the performance requirements of IEEE 837, latest revision. The connectors shall be clearly marked with the manufacturer and conductor size. The installation of the connectors shall be made with a compression, tool and die system, as recommended by the manufacturer of the connectors. Each connector shall be factory filled with an oxide-inhibiting compound.

Screwed or bolted clamp style grounding connectors are not acceptable.

F. Solid State Decouplers shall be UL listed for grounding electrical equipment. Units shall be enclosed in fiberglass housing and be rated for an AC fault current of 1.2 kA. Solid State Decouplers shall be manufactured by Dairyland Industries.

### 2.24 MANHOLES AND PULL BOXES

A. Manholes and pull boxes shall be of precast concrete, designed for H-20 traffic loading. Concrete sections shall be modular with tongue and groove joints. A continuous waterproof gasket shall be provided at all section and slab joints. Manholes and pull boxes shall be equipped with galvanized steel pulling irons opposite each duct bank entrance. Manholes and pull boxes shall be provided with a sump opening and 1" ground rod opening in the base section. Sump openings shall be provided with cast iron perforated covers.

B. Unless indicated otherwise on the Drawings, manhole covers shall be cast iron, 30" round (minimum), and supported on the necking section. Pull box covers shall be hot dipped galvanized checkered plate steel, and shall be bolted down to cast-in hot dipped galvanized steel frames with stainless steel hardware. Unless noted otherwise, manhole and pull box covers shall be designed for H-20 traffic loading and shall be marked with raised lettering according to their contents (e.g. "480V Power", "Control & Instrumentation"). Cover markings shall be confirmed with the District prior to fabrication.

C. Manholes and pull boxes shall be provided with slotted galvanized steel channel inserts cast-in interior walls for conductor/cable supports. Sufficient inserts shall be provided to allow support of conductors/cables at 3-foot (maximum) intervals.

D. Manholes and pull boxes shall be provided with knockouts for connections to all underground conduit and duct banks.

E. Manholes and pull boxes shall be manufactured by Jensen Precast, Oldcastle Precast, or equal.
2.25 **NAMEPLATES**

Plastic nameplates shall be provided for all electrical panels, MCCs, switchboards, panelboards, individually enclosed disconnect switches, individually enclosed circuit breakers, manual starters, control panels, control stations, junction boxes, termination enclosures, receptacles, local switches, and field instruments, unless otherwise indicated on the Drawings or specified in individual specifications for respective equipment.

All nameplates shall be NEMA ES-1, 3-ply, 1/16-inch thick, beveled and satin finished and shall be securely fastened with stainless steel drive screws or escutcheon pins. Nameplates shall be as manufactured by Brady, or equal.

A. **Nameplates**

The nameplates shall be laminated black plastic with 1/4-inch high (unless otherwise specified) white letters. Nameplate inscriptions shall include the identifications for the equipment and loads, and shall identify the controls on control equipment as shown on the Drawings. Nameplate inscriptions on receptacles and local switchplates shall include the panelboard number and circuit that the device is connected to, e.g., "LP A-1". Nameplates on receptacles and local switchplates shall have 3/16-inch high letters.

B. **Lockout/Tagout Nameplates**

Lockout/tagout nameplates shall be provided for all pumps and other mechanical equipment where multiple devices including, but not limited to: switches, circuit breakers, by-pass contactors, VFDs, solid state starters, etc., may cause the equipment to be energized. Said nameplates shall be installed over the main circuit breaker or disconnect switch which will solely remove power from the equipment and all appurtenant controls and circuitry contained in the panel negating the possibility of power being applied by another source.

The nameplate shall be laminated red plastic with 3/8-inch high (unless otherwise specified) white letters. The inscription shall read "LOCKOUT/TAGOUT LOCATION FOR ________" with a description identifying the equipment (e.g. "PUMP P-1").

2.26 **MISCELLANEOUS MATERIALS AND COMPONENTS**

A. **Conduit Tags**

All conduits shall be identified with tag number. The conduit tag shall be a one-inch (1") minimum diameter Type 316 stainless steel or brass disc. The tag shall be stamped with the conduit's number for that respective conduit as indicated on the Drawings. The tag shall be attached to the conduit with a stainless steel chain or stranded mechanic wire.
B. **Thread Lubricant**

1. Thread lubricant shall be provided for all threads in metal conduit, fittings, bodies, boxes, etc. The lubricant shall prevent thread galling, inhibit corrosion and maintain grounding continuity.

2. General purpose lubricant shall be provided on any metal-to-metal threaded joint. General purpose lubricant shall be Crouse-Hinds STL, Thomas and Betts Kopr-Shield, or equal.

3. High temperature lubricant shall be provided on lighting fixture threaded joints and on threaded joints of enclosures of any heat-producing apparatus or control. The lubricant shall be effective and stable from -70 to +1800 °F. The lubricant shall be Crouse-Hinds HTL, or equal.

C. **Conductor and Cable Pulling Lubricant**

Conductor and cable lubricant shall be provided to ease the pulling of conductors and cables in conduits. The pulling lubricant shall be a high performance, temperature stable, non-staining lubricant. The pulling lubricant shall be compatible with all proposed conductor and cable jackets. Conductor and cable manufacturer approvals shall be provided upon District’s request. The pulling lubricant shall not contain wax, grease, silicone, or glycol oils. Conductor and cable pulling lubricant shall be American Polywater Corporation, "Polywater J", or equal.

**PART 3 - EXECUTION**

3.01 **GENERAL**

Contractor shall provide all conduit/conductor installations and equipment installations, including connections and interconnections, as indicated on the Drawings and specified herein, and required for complete and fully operational equipment systems.

A. **Electrical Materials and Products**

Installation of all electrical materials and products shall conform to the requirements of the manufacturer's specifications and installation instructions. When code requirements apply to installation of materials and equipment, the more stringent requirements, code, or manufacturer's specifications and installation instructions shall govern the work.
B. **Power Supplies to Mechanical Equipment**

1. An electric power supply, including conduit, any necessary junction or outlet boxes, and conductors and connections shall be furnished and installed by Contractor for each item of electric motor driven mechanical equipment.

2. Circuit breakers or fused disconnect protection shall be provided for each separate item of electric motor driven mechanical equipment shown on the Drawings, or specified in other sections of the specifications for furnished equipment.

3. Power supplies to individual items of equipment shall be terminated in a suitable outlet or junction box adjacent to the respective item of equipment, or a termination box provided by the manufacturer of the equipment. Sufficient lengths of conductor at each location shall be provided to permit connection to equipment without damaging the conductors.

C. **Excavations and Backfills**

Earthwork shall be performed for underground conduits, manholes, pull boxes, equipment foundations, and supports, as indicated on the Drawings and specified herein, and as specified in Division 2 of the Specifications.

D. **Concrete**

Concrete shall be provided for electrical equipment foundations, support foundations and conduit encasements, as indicated on the Drawings and specified herein, and as specified in Division 3 of the Specifications. Concrete shall be Class C, 2,000 psi red colored concrete per District Detailed Provision, Section 03300, Cast-in-Place Concrete.

E. **Painting**

Painting shall be provided for installations having unfinished surfaces as specified in Division 9 of the Specifications. Field damaged factory finishes on equipment shall be touched-up with paint that is equal in quality and color to the original factory finish.
3.02 CONDUCTORS AND CABLES

Unless indicated otherwise on the Drawings, conductors and cables shall be furnished and installed as specified herein.

A. General

1. Conductors for power feeders, lighting feeders, lighting circuits, and receptacles shall be #12 AWG minimum. Conductors for control circuits shall be #14 AWG minimum.

2. Contractor shall install conductors and cables in accordance with the manufacturer’s written instructions. Contractor shall exercise care to protect conductors and cables. Contractor shall avoid: kinking the conductors; cutting, puncturing, or scraping the insulation or jacket; contamination with oil or grease; or any other damage.

3. All conductors and cables shall be installed in conduit, cable trays, wireways, or electrical enclosures. Conductors and cables shall not be installed in conduit runs until all work is completed for each individual conduit run.

4. Apply cable pulling lubricant to ease and reduce the tension stresses when pulling conductors and cables in conduits, except when installing no-lube wire. The conductors and cables shall be free of debris (dirt, mud, etc.) before being pulled into the conduits. Manufacturers recommended pulling tensions shall not be exceeded. Proper and standard pulling techniques shall be used in pulling in the conductors and cables. Conductors and cables shall not be pulled into the conduit using a vehicle draw or tow bar, tow ball, or non-tension devices. Tensioning devices shall have pressure gauges to indicate pulling tensions being exerted on the conductors and cables during the pulling process. Pulling tension shall be continuously monitored during the duration of pulling. Conductor insulation damage will result in the conductors not being approved for energizing. Conductors and cables not passing megger or hi-pot testing or that have insulation damage shall be replaced with new conductors and cables at no additional cost to the District. Repairing of damaged conductor or cable insulation will not be approved.

5. Conductors and cables shall not be pulled tight against bushing nor pressed heavily against enclosures.

6. To prevent loading on cable connections, where cables are installed vertically, cables shall be supported by stainless steel woven grips, Kellems, or equal. In addition, stainless steel woven grips shall be provided on all submersible cables in wet wells to support cable weight and avoid stress on cable insulation.
7. All conductors or cables in conduit, over 1 foot long, or with any bends, shall be pulled in or out simultaneously.

8. Circuit to supply electric power and control to equipment and devices are indicated on the Drawings. Conductors in designated numbers and sizes shall be installed in conduit of designated size. Circuits shall not be combined to reduce conduit requirements unless approved by the District.

9. All field wiring to/from MCCs, VFDs, and control panels shall terminate at terminal strips in the respective panels and buckets.

10. Furnish and install conduit and conductors as shown on the Drawings, as shown on the control diagrams, and as listed on the "Schedule of Conduit and Conductors" Drawing. Contractor is advised that not all conduit and conductors are listed in the Schedule (particularly 120V lighting and receptacles) and that not all conduits and conductors listed in the Schedule are specifically labeled or called out on other Drawings.

11. Contractor is advised that interconnecting wiring within and between the lineup of MCCs, VFDs, and control panels is not specifically listed or shown on the Drawings. Contractor is directed to the control diagrams and interconnection diagrams on the approved shop drawings. Wiring for said connections shall run within the MCC, VFD, and control panel wireways, or in conduit between MCCs, VFDs, and control panels.

12. Install continuous circuit conductors from source to load without splices or terminations in intermediate junction boxes, manholes, or pull boxes.

B. Splicing and Terminating

1. Where authorized by the District, splices may be made only at accessible locations.

2. Conductors #10 AWG and smaller for lighting and receptacles may be spliced in junction boxes, outlet boxes, and conduit bodies. Lighting and receptacle conductors shall be spliced with tapered coil spring type connectors.
3. Conductors or cable lengths that exceed standard manufactured lengths may be spliced in junction boxes for power conductors or termination cabinets for control and instrumentation conductors. Junction boxes and termination cabinets shall be NEMA 4 in indoor, dry and non-corrosive locations, and shall be NEMA 4X in outdoor, wet, or corrosive locations. Junction boxes and termination cabinets containing splices shall be labeled "Splice". Provide sufficient conductor and cable slack at junction boxes and termination cabinets to make proper splices, and do not pull splices into conduits.

4. Stranded conductors shall be terminated by lugs or compression type connectors. The connectors shall be crimped with a tool that provides uniform and tight connections. Wrapping stranded conductors around screw type terminals is not acceptable.

5. Splices and terminations of #8 AWG and larger conductors, 600 V rated, shall be with non-insulated compression type connectors. Splices and terminations of #10 and smaller conductors, 600 V rated, shall be with pre-insulated compression type connectors.

6. Non-insulated compression type splice connectors shall be taped with two layers of half lapped liner-less rubber splicing tape and provided with a cold shrink connector insulator sleeve (pre-slipped over the conductor) over the splice connector. Cold shrink insulators shall be as manufactured by 3M Company, or equal.

7. Control conductors shall be spliced with pre-insulated crimp type connectors and terminated with split tongue pre-insulated, crimp type connectors.

8. Terminations and splices in all motor terminal boxes shall be made with compression type connectors. Splices to motor leads in the motor terminal boxes shall be compression lug type with motor splice boots to serve as insulators.

9. Splices in underground manholes and pull boxes will not be allowed.

10. All conductors and cables in electrical panels, MCCs and equipment enclosures shall be neatly bundled and fastened.

C. Grounding

1. Grounding shall be provided as shown on the Drawings and in accordance with the NEC.

2. Where indicated on the Drawings, bare copper conductors shall be installed in a ground ring encircling buildings or structures in direct contact with the earth. The
ground ring shall be placed under building or structure footing and be buried at a depth below the earth's surface of not less than 30". When installed beneath building foundation, provide a minimum 3" earth cover from bottom of footing.

3. Ground rods shall be installed as shown on the Drawings and specified herein. Provide additional rods as applicable to all service entrances, transformers, building/structure ground rings, manholes, pull boxes, etc. as required to obtain a maximum ground resistance of 15 ohms at each location. Ground continuity shall be maintained through all manholes and pull boxes. All metal parts in manholes and pull boxes shall be connected to the grounding system.

4. Copper to copper exothermic welded connections (Cadweld) shall be provided for connections between multiple copper grounding conductors, such as equipment ground conductors, buried ground conductors, and building/structure ground rings. Copper to steel Cadweld connections shall be provided for connections between copper grounding conductors and copper-clad steel ground rods, steel rebar mats, steel pipes, and other steel surfaces as indicated on the Drawings.

5. Where indicated on the Drawings, copper conductors not smaller than #4 AWG shall be connected to steel rebar mats of concrete slabs and building floors to supplement the grounding electrode system. Solid State Decouplers shall be installed to provide cathodic protection between the rebar mats and copper conductors.

6. Enclosures of equipment, raceways and fixtures shall be permanently and effectively grounded. A code-sized, copper, insulated green equipment ground shall be provided for all branch circuit and feeder runs. Equipment grounds shall originate at MCC ground bus and shall be bonded to all junction boxes and electrical equipment enclosures. Similarly, equipment grounds shall originate at panelboard ground bus and shall be bonded to all switch and receptacle boxes, and electrical equipment enclosures. Ground terminals on receptacles shall be connected to the equipment grounding conductor by an insulated copper conductor.

7. All flexible conduits shall be provided with an insulated green copper ground conductor, #12 AWG, unless indicated otherwise on the Drawings.

8. Bonding conductors shall be installed between all raceways, enclosures, wireways, and cable trays.

9. Grounding bushings shall be installed on all conduit terminations, including conduit directly connected to enclosures and conduit stubbed up into block-out areas for free standing enclosures. A bonding conductor, #8 AWG minimum, shall be provided between all conduit ground bushings and enclosure ground.
10. SCE equipment grounding shall be provided and installed as required by SCE.

D. Identification

1. All conductors and cables shall be marked with wire markers at each end and at each intermediate junction box, pull box, manhole or enclosure, except for short "jumper" wires. Wire markers shall indicate the designation/destination of the conductors/cables. Example being-LPA CB1 - REC1 to indicate lighting panel A, circuit breaker #1 to receptacle #1; MCCCB4 - MTR4 indicating Motor Control Center Breaker #4 to Motor #4; etc.

2. Wire markers for conductors and cables shall be heat shrinkable identification sleeves and translucent shrink tubes, as specified herein.

3. Where more than two conductors run through a single outlet, each circuit shall be marked with the corresponding circuit number at the panelboard.

4. Conductors size #6 AWG and larger shall be color coded using specified phase color markers and shall be provided with identification markers.

5. All terminal strips shall have each individual terminal identified with printed markers.

6. All receptacles and switches shall be provided with plastic decal labels on the cover plate, denoting the lighting panel and circuit number.
### 3.03 CONDUIT MATERIAL SCHEDULE

The required conduit material(s) for the project shall be as indicated on the Drawings. In addition, Contractor shall comply with the following Conduit Material Schedule for permitted materials for various locations and uses.

<table>
<thead>
<tr>
<th>Location or Use</th>
<th>Conduits Permitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground (not under building slabs, foundations, or concrete slabs on grade)</td>
<td>Concrete encased PVC conduit with PVC-RGS or PVC-RA conduit for horizontal bends, 90 degree stub ups and risers.</td>
</tr>
<tr>
<td>Under building slabs, foundations, or concrete slabs on grade</td>
<td>PVC (see below for concrete footing requirements)</td>
</tr>
<tr>
<td>1. In building concrete slab (if min. 12&quot; thick) or concrete footings</td>
<td>PVC-RGS, PVC-RA conduit (min. 1&quot; clearance to all rebar)</td>
</tr>
<tr>
<td>1. In concrete walls or masonry walls</td>
<td>PVC, PVC-RGS, PVC-RA</td>
</tr>
<tr>
<td>In steel stud or wood stud walls</td>
<td>RGS, RA</td>
</tr>
<tr>
<td>In ceiling or attic space</td>
<td>RGS, RA</td>
</tr>
<tr>
<td>Exposed outdoors</td>
<td>RGS, RA</td>
</tr>
<tr>
<td>Exposed outdoors, corrosive locations</td>
<td>PVC-RGS, PVC-RA</td>
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<tr>
<td>Exposed outdoors, hazardous locations</td>
<td>PVC-RGS, PVC-RA</td>
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<tr>
<td>Exposed indoors, dry locations</td>
<td>RGS, RA, RSS</td>
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<tr>
<td>Exposed indoors, damp or wet locations</td>
<td>PVC-RGS, PVC-RA, RSS</td>
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<td>Exposed indoors, hazardous locations</td>
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<tr>
<td>Exposed belowgrade, dry locations</td>
<td>RGS, RA, RSS</td>
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<tr>
<td>Exposed belowgrade, damp or wet locations</td>
<td>PVC-RGS, PVC-RA</td>
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<tr>
<td>Exposed belowgrade, sewage wet wells</td>
<td>RSS</td>
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</table>

1. Conduit shall be cast in concrete or in masonry walls only where specified on the Drawings.

### 3.04 CONDUIT

Unless indicated otherwise on the Drawings, conduit shall be installed as specified herein.

A. **General**

1. Contractor shall install conduit and electrical equipment in locations that will cause minimal interference with the maintenance and removal of mechanical equipment. Conduits and connections are shown schematically on the Drawings. Contractor shall run conduit in a neat manner parallel or perpendicular to walls and slabs, and wherever possible, installed together in parallel runs supported with strut channel support system. All conduits shall be installed plumb, straight, and true with reference to the adjacent work.
2. Unless indicated otherwise on the Drawings, conduits shall be concealed underground, under concrete slabs and footings, or exposed mounted on walls and ceilings. Concealed conduits shall be run in as direct a route as possible and with bends of large radii. Floor penetrations shall be made only at specific approved locations; other penetrations are prohibited.

3. Locations of conduit runs shall be planned in advance of the installation and coordinated with the electrical panel lineup furnished, ductwork, plumbing, ceiling, wall, and footing construction in the same areas. Conduits shall not unnecessarily cross other conduits or pipe, nor prevent removal of nor block access to mechanical or electrical equipment.

4. Minimum conduit size shall be 3/4". Where device or instrument connection size is 1/2", Contractor shall provide the necessary fittings for connection. Alternatively, Contractor may provide 1/2" liquid-tight flexible conduit.

5. Belowgrade (buried) conduit shall be installed with a minimum of 27" cover, including conduit under structures and concrete slabs on grade. Where change in direction is required, long radius elbows shall be installed. Buried conduit shall be installed using approved spacers and cradles. Conduit shall be properly supported/anchored and at sufficient intervals to prevent movement during encasement operations (maximum spacing of 5').

6. Buried conduit shall be completely encased in concrete, including conduit under structures and concrete slabs on grade, and SCE conduit located on District property. Concrete shall be provided with an integral red dye coloring. Provide at least 3 inches of concrete cover from the outside of the conduits to the outside of the encasement. Top of concrete encasement shall be a minimum of 24" below grade. Backfill above concrete encasement shall be compacted to a minimum of 90% relative compaction.

Conduits shall be installed beneath concrete slabs on grade, footings, or trenches with a minimum of 6" clearance between conduit and bottom of concrete. Conduit backfill where installed beneath concrete shall be two sack sand-cement slurry from the top of concrete encasement to subgrade.

Conduit shall be cast in concrete or in masonry walls only where specified on the Drawings.
7. Buried conduit shall be supported by modular, interlocking, plastic spacers prior to placing concrete for duct bank encasement. Spacers shall be installed in accordance with the manufacturer’s printed instructions and shall be located to maintain a uniform separation between conduits throughout the duct bank alignment.

8. Where power and control/instrumentation conduits are routed in the same duct bank, configure the conduits within the duct bank to provide a minimum separation of 6" between power and control/instrumentation conduits.

9. Prior to installation of conductors in underground conduits, a testing mandrel not less than 6" long and with a diameter 1/4" less than the conduit diameter shall be drawn through after which a stiff bristle brush of the proper size for the conduits shall be drawn through until the conduits are free of all sand and gravel.

11. Where Schedule 40 or Schedule 80 PVC conduit is permitted, horizontal bends and vertical risers and bends shall be PVC-RGS or PVC-RA. Vertical risers and bends shall be completely encased in concrete to finished grade.

12. Where conduit is stubbed through concrete slabs or footings into electrical panels (MCCs, VFDs, switchboards, etc.), a minimum of 1-1/2" clearance shall be provided between rebar and conduit and a minimum of 1" clearance shall be provided between conduits. Adjust rebar spacing as necessary to a maximum of one-half the nominal spacing such that maximum rebar spacing does not exceed 1-1/2 times that specified. The total amount of reinforcing steel shall not be reduced.

13. Prior to installation of conduit, Contractor’s submittals for: basic electrical materials, MCCs, VFDs switchboards, panelboards, and control panels shall be accepted by the District.

14. Conduits shall terminate within the respective MCC/electrical panel section, or in adjacent section if additional space is required. Contractor shall adjust location of conduit terminations based on accepted MCC/electrical panel layout.

15. Spare conduits shall be provided with threaded plugs or caps and polyester pull line attached to the threaded plug/cap or enclosure (as applicable).

16. All conduits shall be tightly sealed during construction by use of conduit plugs or "pennies" set under bushings. All conduit in which moisture or any foreign matter has collected before pulling conductors shall be cleaned and dried to the satisfaction of the District.
17. Conduits shall be securely fastened to enclosures, cabinets, boxes, and wireways using hubs and locknuts, and an insulating bushing or specified insulated connectors.

18. All conduits shall be labeled with stainless steel or brass tags as specified herein. Tags shall be stamped with the conduit's number for that respective conduit as indicated on the Drawings. Conduit shall be labeled at both ends and at all intermediate connection points to junction boxes, wireways, pull boxes, and manholes.

Buried conduit shall be labeled within free standing panels, pull boxes, and manholes. Exposed conduit shall be labeled before they enter junction boxes, wireways, wall mounted panels, etc.

19. Aboveground and underground power feed conduits from VFDs to electric motors or from rectifiers to electrical equipment shall be PVC-RGS or PVC-RA.

20. Conduit and device boxes installed abovegrade in buildings shall be surface mounted.

21. Conduit and enclosures shall be installed with a minimum clearance of 12” to hot pipes or surfaces (150°F or higher).

22. Ground conductors shall be installed in all metallic and non-metallic conduits.

23. In addition to grounding conductors, bonding conductors shall be provided on all metallic conduits, device boxes, and enclosures.

B. Liquid-Tight Flexible Metallic Conduit

1. Liquid-tight flexible conduit shall be installed in all locations for connections to equipment, including, but not limited to: motors, HVAC equipment, automatic valves, and similar devices. Liquid-tight flexible conduit length shall not exceed 36” at connections to equipment.

2. Liquid-tight flexible conduit connectors and fittings installed in PVC-RGS or PVC-RA systems shall be PVC coated.

3. A separate ground conductor shall be installed in flexible conduit that does not have an internal copper bonding conductor included by the manufacturer, or where indicated on the Drawings.

4. Stainless steel braided flexible conduit rated for Class 1, Division 1 locations shall be installed in hazardous locations per NEC Article 501 requirements.
C. Rigid Non-Metallic Conduit

1. Schedule 40 or 80 PVC conduit may be used underground where permitted. PVC conduits shall not be run exposed.

2. Ground conductors shall be installed in all non-metallic conduits.

3. Where Schedule 40 or Schedule 80 PVC conduit is permitted, all horizontal and vertical bends, and vertical risers shall be PVC-RGS or PVC-RA. All belowgrade horizontal bends and vertical bends shall be long radius elbows. Bending of straight PVC conduit to avoid installation of the specified PVC-RGS or PVC-RA long radius elbows will not be allowed.

4. Where conduit transition from nonmetallic to metallic is required, provide nonmetallic threaded adapters.

D. Metallic Conduit (RGS and RA)

1. All RGS and RA conduit and fittings in direct contact with the ground, concrete, or grout shall be PVC coated as specified herein. Alternatively, RGS and RA conduit may be protected by double wrapping with 20 mil polyvinyl-chloride (PVC) tape.

2. Defects and scratches on exposed RGS conduit shall be repaired with hot stick galvanizing solder, Galva-Guard, or equal.

E. PVC Coated Metallic Conduit (PVC-RGS and PVC-RA)

1. All device boxes, conduit bodies, cover plates, conduit straps, conduit fittings, and liquid-tight connectors installed in PVC coated metallic conduit systems shall be PVC coated.

2. Cut or damaged PVC coating shall be repaired in strict accordance with the manufacturer’s written repair procedures to maintain the integrity of the 40 mil PVC coating system. Repair sprays or paint will not be acceptable.

F. Termination and Joints

1. Conduit shall be joined using specified couplings or transition couplings where dissimilar conduit systems are joined.

2. Conduit terminations at boxes enclosures and boxes shall be water-tight and dust-tight. Conduit terminations shall be made using approved gasketed connectors and hubs.
3. Expansion couplings shall be installed where any conduit crosses a building separation joint.

4. At all conduit terminations and connections to cabinets, boxes and enclosures, etc., conductors shall be protected by a fitting equipped with a plastic bushing having a smoothly rounded insulating surface.

G. **Threads**

1. All metal conduit cut ends shall be reamed or otherwise finished to remove rough edges.

2. Where conduit is threaded in the field, a standard cutting die with NPT tapered threads (3/4-in. taper per foot) shall be utilized to provide full cut threads. Running threads are not acceptable.

3. All male threads on metallic conduit and fittings shall be coated with a thread lubricant before installing connections. The thread lubricant shall be as specified herein. All connections shall be made watertight.

4. Any exposed threaded surface on RGS conduit shall be thoroughly cleaned with solvent to remove any residual lubricant or other contaminants, and shall then be completely coated with a zinc rich cold galvanizing coating, CRC Zinc-It Cold Galvanize, or equal.

H. **Locknuts and Bushings**

Locknuts and bushings shall be installed on the threads of metal conduits that enter through close-fit openings in enclosures.

I. **Seal Fittings**

1. Seal fittings shall be connected to rigid metal conduits in hazardous areas to prevent gases and flames from passing from one area to another through the conduit system. Hazardous areas shall be as defined by NEC, Article 500.

2. Seal fitting locations shall be in accordance with NEC, Article 501.

3. Unless specified otherwise, install seal fittings not less than 4 inches from finish floor or wall, but not more than 18 inches.
J. **Stub-Ups**

1. Unless indicated otherwise herein or on the Drawings, all indoor and outdoor conduit stub-ups shall be provided with a threaded coupling, and shall extend 2” above slab, grade, or structure.

2. Exposed conduit, stubbing up through floor slabs or slabs on grade into the bottom of exposed panels, cabinets, or equipment, shall be properly aligned and spaced for connection to same, and shall be straight and plumb. Offset rigid conduit or flexible conduit installed with an offset will not be allowed. Conduits shall be installed at sufficient depth below slab to eliminate any part of the bend above top of slab.

3. Where spare conduit is stubbed through concrete slabs adjacent to walls or equipment, conduit shall extend approximately 2” above the top of the concrete slab and shall be provided with a threaded coupling and plug.

Where spare conduit is stubbed through concrete slabs in open floor areas, conduit shall be provided with a threaded coupling and plug installed flush with the finished floor.

K. **Conduit Through Roof**

Provide a watertight seal around conduits that penetrate through the roof. Coordinate the conduit installation work with the roofing installation.

L. **Duct Banks**

1. Contractor shall be responsible for layout/configuration of duct banks and coordination of pull box sizes. Proposed duct bank layouts and cross sections shall be submitted to District for review prior to commencing installation. Contractor’s as-built drawings shall include cross sections (drawn by Contractor) of all electrical duct banks. Said duct bank cross sections and as-built drawings shall be prepared as the project proceeds and shall be reviewed by Contractor with District at least monthly.

2. Complete as-built electrical duct bank drawings shall be submitted to District upon completion of construction.
M. Labeling

Contractor shall field number and label all conduits and provide complete as-built drawings to District. All conduits within manholes and pull boxes shall be permanently labeled therein and labeled where they stub up to an MCC, switchboard, panelboard, VFD, control panel, cabinet, or junction box. Conduits shall be labeled with brass or stainless steel tags attached to conduit with stainless steel stranded wire.

3.05 CONDUIT FITTINGS, BOXES, AND WIRING DEVICES

Conduit fittings, outlet boxes, wiring devices, and appurtenances shall be installed as indicated on the Drawings, specified herein, and required.

A. Materials

1. Conduit fittings, outlet bodies, outlet boxes, and device boxes shall be constructed of ferrous metal, aluminum, or stainless steel. Materials provided shall be consistent with the conduit material being used (i.e. ferrous metal with RSG conduit, aluminum with aluminum conduit, and stainless steel with stainless steel conduit).

2. Where PVC coated conduit systems are specified, all conduit fittings, outlet bodies, outlet boxes, and device boxes shall be PVC coated.

B. Hubs

1. Enclosures without integral hubs shall be provided with close-fit holes for conduit connections. Conduit connections shall be made with water-tight and dust-tight hubs.

2. Hubs shall be furnished with vibration-proof nuts equipped with grounding screws.

3. All hub ground nuts in an enclosure shall be bonded with a ground conductor (green insulated #12 AWG, minimum) to the enclosure ground.

C. Boxes

1. All outlet boxes and device boxes shall be surface mounted on walls, ceilings, and floors, except where indicated on the Drawings to be concealed and finished flush.
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2. Outlet boxes and device boxes specified to be finished flush in concrete, masonry, or gypsum board covered walls shall be furnished with box extensions as necessary to provide a flush finished installation for the box cover plates. Pressed steel boxes shall be wrapped with PVC tape to prevent concrete or grout from entering the box through unused holes or knockouts during placement operations.

3. Cast device boxes shall be provided for all toggle switches and receptacles.

4. No unused openings shall be left in any box. Close-up plugs shall be installed as required to seal openings.

5. Boxes in outdoor, damp, and wet locations shall be provided with gasketed, cast metal cover plates.

6. Device boxes for convenience receptacles and switches in damp locations shall be provided with self-closing, gasketed, cast metal cover plates.

7. Device boxes for convenience receptacles in outdoor and wet locations shall be provided with gasketed, cast metal, weatherproof, extra duty rated, in-use type cover plates.

D. Box Layout

1. Outlet and device boxes shall be installed at the locations and elevations shown on the Drawings or specified herein. Adjustments to locations shall be made as required by structural conditions and to suit coordination requirements of other trades. Where specified to be flush mounted on concrete masonry wall, center box in course of concrete block.

2. Unless indicated otherwise on the Drawings, device boxes for convenience receptacles shall be installed 18" above finished floor or finished grade.

3. Unless indicated otherwise on the Drawings, device boxes for toggle switches shall be installed 48" above finished floor or finished grade.
3.06 MANHOLES AND PULL BOXES

A. As a minimum, underground manholes and pull boxes shall be sized and located as indicated on the Drawings. Depending on the Contractor's duct bank routings and configurations, additional or larger manholes and pull boxes may be necessary. Manhole/pull box knockout areas shall be sized according to Contractor's duct bank configurations and dimensions. Contractor shall be responsible for coordinating manhole and pull box sizes and knockout dimensions/locations with the manufacturer. All costs for additional, larger, or custom manholes and pull boxes shall be borne by the Contractor.

B. Place bottom of manholes and pull boxes on 12" thick (minimum) graded 3/4" crushed rock compacted to 95% relative compaction. Unless noted otherwise, provide crushed rock (2' deep by 2' square) beneath each drain sump, and knock out concrete sump bottom for drainage.

C. Install a continuous waterproof gasket at all manhole and pull box section and slab joints.

D. Manholes and pull boxes shall be provided with conductor/cable supports as required to support conductors/cables at 3-foot (maximum) intervals. Supports shall be fabricated from hot dipped galvanized or fiberglass strut channel and attached to cast-in channel inserts. Provide glazed porcelain insulators with channel clamps for support channels. Strap conductors/cables to insulators with plastic tie wraps. All phase and ground conductors in each circuit shall be kept together and contained on/in the porcelain insulators. No phase conductors shall be run separate from the other two phases and ground.

E. All duct bank and conduit penetrations shall be grouted all around with non-shrink grout. Non-shrink grout shall be finished flush with the interior wall surface. All conduits shall be terminated with flush-end bells.

F. One ground rod shall be provided for each manhole and pull box. Provide a #4/0 bare stranded copper ground wire completely around the inside perimeter of each manhole and pull box, and anchor the ground wire to walls. Connect the ground wire to the ground rod. Bond the bare copper ground wire to any splice shield wires, ground wires, metal cable racks, cover frames, sump frames and other metal items in the manholes. All separate ground wires accompanying circuits shall be grounded in each manhole or pull box passed through.
3.07 CABLE TRAY INSTALLATION AND TESTING

A. Cable trays shall be installed as indicated on the Drawings and as specified herein. Installation shall be in accordance with equipment manufacturer's instructions, and with recognized industry practices, including NEMA VE-2, to ensure that cable tray equipment comply with requirements of NEC and applicable portions of NFPA 70B.

B. Coordinate cable tray installation with other electrical work as necessary to properly integrate cable tray work with other work.

C. Provide sufficient space encompassing cable trays to permit access for installing and maintaining cables.

D. Cable tray fitting supports shall be located such that they meet the strength requirements of straight sections. Install fitting supports per NEMA VE-2 guidelines, and in accordance with manufacturer's instructions.

E. Test cable trays to ensure electrical continuity of bonding and grounding connections, and to demonstrate compliance with specified maximum grounding resistance. Testing and test methods shall be in accordance with NFPA 70B, Chapter 18.

F. Manufacturer shall provide test reports witnessed by an independent testing laboratory of the "worst case" loading conditions outlined in this specification and performed in accordance with the latest revision of NEMA VE-1; including test reports verifying rung load capacity in accordance with NEMA VE-1, Section 5.4.

3.08 PANELBOARDS

Panelboards shall be factory assembled, and shall be installed as indicated on the Drawings and specified herein.

A. Panelboards shall be installed 6 feet from grade or floor to top of the enclosure.

B. Provide at least 1/2 inch clearance between the back of the panelboard enclosure and masonry or concrete wall.

C. Securely attach the panelboard to the wall or support structure with anchor bolts or machine bolts.

D. Attach locking devices on the handles of branch circuit breakers for the "ON" position as indicated on the Drawings.

E. Completely type the directory card to identify each connected and spare circuit.

F. Provide tight connections for all feeder and branch circuit conduit and wiring.
3.09 TRANSFORMERS

A. Transformers shall be installed in accordance with manufacturer's printed instructions, including minimum clearances for ventilation and cooling. Transformers installed against a wall shall have readily accessible primary and secondary terminals.

B. Transformers shall be installed on vibration pads designed to suppress the transformer vibrations. Pads shall be selected based on the actual transformer weight and a minimum safety factor of 2:1. Vibration pads shall be located in accordance with the manufacturer's recommendations.

C. Conduit connections to the transformer shall be with liquid-tight flexible conduit.

D. During startup and testing, Contractor shall obtain primary and secondary voltage readings, and if necessary, tap connections shall be adjusted to provide the specified nominal supply voltage.

3.10 DISCONNECT SWITCHES

Disconnect switches shall be factory assembled, and shall be installed as indicated on the Drawings and specified herein.

A. Disconnect switches shall be installed 5 feet from grade or floor to the top of the enclosure.

B. Securely attach disconnect switches to walls or support structures with anchor bolts or machine bolts.

3.11 SUPPORTS

Unless indicated otherwise on the Drawings, electrical conduit, boxes, enclosures, cabinets, panels, and equipment shall be supported as specified herein.

A. Install the required strut channels, fittings, clamps, U-bolts, hangers, anchors, hangers, fittings, and other hardware to securely attach and support all the equipment and conduits. Unless indicated otherwise on the Drawings, all support materials shall be steel, malleable iron, or other ferrous metals, and shall be hot dipped galvanized after fabrication. Where indicated on the Drawings, support material shall be fiberglass, stainless steel, or PVC coated steel and malleable iron.

B. Exposed conduit shall be supported with strut channel, clamps, and hanger supports spaced per NEC requirements (8'-0" maximum spacing) and within 18" of couplings, bends, enclosures, boxes, etc.
C. Multiple conduit runs shall be supported using "trapeze" hangers, consisting of approved strut channels suspended on 3/8" (minimum) steel rods from beam clamps or ceiling inserts located not more than 8' apart. Sizes of channels and rods shall be selected as recommended by the manufacturer for span and loading conditions.

D. Unless indicated otherwise on the Drawings, Contractor shall use Type 304 stainless steel fasteners and anchors, including wedge anchors, sleeve anchors, epoxy anchors, machine bolts, etc., for mounting electrical equipment and conduit. No type of explosive anchor will be permitted.

E. Strut channel shall be neatly cut and provided with squared ends. All burrs shall be removed and sharp edges shall be rounded. Channel ends shall then be treated as follows:

1. Hot dipped galvanized strut channel - solvent clean to remove any contaminants and coat with a zinc rich cold galvanizing coating, CRC Zinc-It Cold Galvanize, or equal.

2. Fiberglass strut channel - seal with fiberglass resin in accordance with the manufacturer's recommendations.

3. PVC coated pre-galvanized strut channel - solvent clean to remove any contaminants and coat with PVC repair coating in accordance with the manufacturer's recommendations.

4. Stainless steel strut channel - no additional treatment required.

### 3.12 NAMEPLATES

A. Plastic nameplates shall be positioned and lined-up to provide a neat appearance. They shall be attached to the cleaned metal surfaces of enclosures with stainless steel machine screws or escutcheon pins. Nameplates shall be attached to receptacle and local switch cover plates with an adhesive or equal for circuit identification and placed above the device.

B. Nameplates shall be installed on all motor control centers, switchboards, panelboards, individually enclosed circuit breakers and disconnect switches, control panels, control stations, junction boxes, termination cabinets, toggle switches, and convenience receptacles.
3.13 CUTTING AND REPAIRING

A. Where conduit installation requires penetrating existing concrete or masonry structures (walls, floors, or ceilings), Contractor shall core drill the existing structure and fill the remaining annular space with non-shrink grout.

B. Other demolitions methods for other cutting or removing shall be approved by the District prior to commencing the work. Contractor shall repair all damage to remaining facilities caused said demolition to the satisfaction of the District.

3.14 DISSIMILAR METALS

A. Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action.

B. Wherever dissimilar metals come in contact, Contractor shall isolate these metals as required with neoprene washers or gaskets.

C. Where fastening aluminum items, stainless steel bolts shall be used.

D. Wherever steel and aluminum join, isolation bushings shall be used to separate these dissimilar metals and grounding jumpers shall be provided across these joints.

3.15 WORKMANSHIP

A. Preparation, handling, and installation shall be in accordance with manufacturer's written instructions and technical data particular to the product specified and/or approved, except as otherwise specified.

B. Work shall be furnished and placed in coordination and cooperation with other trades.

C. Work shall conform to the National Electrical Contractors Association Standard of Installation for general installation practice.

3.16 PROTECTION DURING CONSTRUCTION

A. Conduits, junction boxes, outlet boxes, and other openings shall be kept closed to prevent entry of foreign matter.

B. Fixtures, equipment, and apparatus shall be covered and protected against dirt, paint, water, chemical or mechanical damage, before and during the construction period.
C. Damaged fixtures, apparatus, or equipment shall be restored to original condition prior to final acceptance, including restoration of damaged shop coats of paint. Brightly finished surfaces and similar items shall be protected until in service. No rust or damage will be permitted.

3.17 CHECKING, ADJUSTING AND TESTING

Provide the required labor and equipment, and all checking, adjusting and testing operations on the electrical installations.

A. Check

All wire terminals shall be checked to assure tight connections.

B. Adjust

Adjust repeat cycle timers, interval timers and time delay relays and other devices so the controls shall operate in the indicated sequence.

C. Wiring Tests

The tests shall be performed to detect wrong connections, short circuits, continuity and grounds. Insulation tests shall be made with a hand crank or battery operated test instrument on all cables, conductors and motors. Power feeders branch conductors and motors shall be tested phase-to-phase, and phase-to-ground. A copy of the test results for feeders and motors shall be submitted to the District when completed (after any deficiencies have been noted and corrected). Correct any installation and electrical defects in the wiring systems.

D. Equipment Tests

Perform equipment tests as indicated and directed by the manufacturer, and as specified in Section 16010 and Sections of the Specification specifying equipment and/or systems.

E. Test Data

Test data for equipment, shielded cables and supply voltage shall be submitted to the District.

F. Supply Voltage

Test the supply voltage while the normal plant loads are operating. If the voltage is not within normal limits (plus or minus one percent), notify the District.
G. **Operation Tests**

Perform operation tests and observe that all electrical loads operate satisfactorily as specified in Section 16010 and Sections of the Specifications specifying equipment and/or systems.

### 3.18 CLEANUP

A. All parts of the electrical materials and equipment shall be left in a clean condition. Exposed parts shall be clean of cement, plaster and other materials, and all oil and grease spots shall be removed with a non-flammable cleaning solvent. Such surfaces shall be carefully wiped and all cracks and corners scraped out. Paint touch-up shall be applied to all scratches on panels and cabinets. Interiors of electrical cabinets or enclosures shall be free of spider webs and shall be vacuumed clean.

B. During the progress of the work, the Contractor shall clean up after his workers and shall leave the premises and all portions of the site in which he is working free from debris and surplus materials.

**END OF SECTION 16050**
SPECIFICATIONS - DETAILED PROVISIONS  
Section 16150 - Induction Motors

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PART 1 - GENERAL

1.01 DESCRIPTION

A. This section specifies the electrical requirements for squirrel-cage induction motors. Motors shall be supplied by the manufacturer of the driven equipment as specified in this section, and specifically outlined in the equipment sections of these Specifications. The requirements of the individual driven equipment sections are equally applicable to the work specified herein. Where conflict exists, the individual equipment sections shall take precedence.

B. Contractor shall furnish and install electric motors, accessories, and appurtenances as specified herein and in conformance with the individual specifications of driven equipment, to provide a complete and operable installation, all in accordance with the requirements of the Contract Documents.

C. The Contractor and equipment manufacturer shall be responsible for providing motors and controls sized in accordance with the requirements specified herein and in the individual equipment sections. Under no circumstances shall the nameplate rating of the motor be exceeded under the maximum design capacity of the equipment supplied. In addition, the motor service factor shall not be used for motor sizing.

1.02 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Sections of the Specifications specifying electric motor driven equipment.
2. Section 16010 - General Electrical Requirements
3. Section 16050 - Basic Electrical Materials and Methods
4. Section 16151 - Vertical Hollowshaft Electric Motors
5. Section 16160 - Variable Frequency Drives
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6. Section 16480 - Motor Control Centers, Switchboards, and Panelboards

7. Section 17005 - General Instrumentation and Control Components

1.03 REFERENCE STANDARDS AND CODES

All equipment and materials, including installation of same, shall meet or exceed the applicable requirements of the following standards and codes (latest edition):

A. American Bearing Manufacturer's Association (ABMA)
   1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings
   2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings

B. Institute of Electrical and Electronics Engineers (IEEE)
   1. IEEE 43 – Recommended Practice for Testing Insulation Resistance of Rotating Machinery
   2. IEEE 85 – Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery
   3. IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators
   5. IEEE 303 – Recommended Practice for Auxiliary Devices for Rotating Electrical Machines in Class I, Division 2 and Zone 2 Locations and Class II, Division 2 and Zone 22 Locations
   7. IEEE 1349 – Guide for the Application of Motors in Hazardous (Classified) Locations

C. National Electrical Manufacturers Association (NEMA)
   1. MG 1 - Motors and Generators
2. MG 2 – Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

3. MG 13 – Frame Assignment for Alternating-Current Integral-Horsepower Induction Motors

D. National Fire Protection Association (NFPA)

1. NFPA 70 - National Electrical Code (NEC)

E. Underwriters Laboratories (UL)

1. UL 674 - Electric Motors and Generators for Use in Hazardous (Classified) Locations

1.04 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A. Shop Drawings

Contractor shall prepare and submit complete information, drawings, and data for motor driven equipment as specified in the individual specification sections for same. Motor submittal information shall be provided as part of the submittals for the driven equipment. As a minimum, motor submittal information, drawings, and data shall include the following:

1. Machine name and specification section number of driven machine.

2. Motor manufacturer, motor type or model.


4. Motor data summary sheet, listing: nominal horsepower; NEMA design; frame size; enclosure type; winding insulation class and treatment; rated ambient temperature; service factor; voltage, phase, and frequency rating; full load current at rated horsepower for application voltage; starting code letter, or locked rotor kVA, or current; special winding configuration such as part-winding, star-delta (include winding diagram); rated full load speed; power factor at full load; noise certification and data sheets (where required); and bearing types and catalog numbers.
5. Motor performance characteristics:
   a. Guaranteed minimum efficiency at rated load at rated voltage.
   b. Guaranteed minimum power factor at rated load at rated voltage.
   c. Expected efficiency at 1/2, 3/4, and full load at rated voltage.
   d. Expected power factor at 1/2, 3/4, and full load at rated voltage.
   e. Full load current at 110 percent voltage.
   f. Starting current at rated voltage (motor locked rotor design code).

6. Motor outline, cross-section, and assembly drawings, with dimensions and motor net weight. Motor wiring diagrams, including wiring for all accessories and components.

7. Motor output shaft diameter, length, keying, drilling, etc. Motor coupling for connection to driven equipment (if applicable).

8. Bearing types and catalog numbers.

9. Special characteristics and features of motor(s) to be supplied.

10. Time in seconds motor can be subjected to locked rotor current at rated voltage without damage to motor with: (1) motor initially at the rated ambient temperature, and (2) motor initially at the rated temperature rise.

11. Thermal protection system (where required) including recommended alarm and trip settings for winding RTDs (if applicable).


13. Motor noise data sheets and certification (where required).

14. Vertical motor data (where applicable):
   a. Thrust bearing life.
   b. Type of thrust bearing lubrication.
   c. Type of guide bearing lubrication.
15. Inverter duty motor data (where applicable):
   a. Manufacturer's inverter duty motor specifications, including motor winding voltage rating.
   b. Maximum distance (in feet) motor may be located from variable frequency drive.
   c. Torque output rating: variable or constant.
   d. Operating speed range, continuous duty.
   e. Motor manufacturer's certification statement that the proposed motor is suitable to drive the selected equipment over the specified speed range with the selected motor.
   f. Motor noise data sheets and certification.

16. Factory test reports, including all factory test results.

B. Operation and Maintenance (O&M) Manuals

Contractor shall prepare a detailed O&M Manual for each type and size of motor required by the individual equipment sections for the driven equipment. Motor O&M Manuals shall be provided as a part of the O&M Manuals for the driven equipment. Equipment O&M Manuals shall be provided in accordance with the requirements of the District's General Conditions and Section 01430.

Motor O&M Manual information and data shall include, but not be limited to, the following:

1. Motor Performance Data and Drawings
   a. Manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, and illustrations.
   b. As-built motor outline, cross-section, and assembly drawings.
   c. As-built motor wiring diagrams, including wiring for all accessories and components.
2. Motor Installation Requirements
   a. Complete, detailed installation instructions for all motors, accessories, and components.
   b. Alignment and adjustment instructions.

3. Motor Service and Maintenance Data
   a. Maintenance data shall include all information and instructions required by District's personnel to keep motors properly lubricated and adjusted.
   b. Unloading, handling, and long term storage requirements.
   c. Explanation with illustrations as necessary for each maintenance task.
   d. Recommended schedule of maintenance tasks.
   e. Troubleshooting instructions.
   f. List of maintenance tools and equipment.
   g. Parts list with part illustrations.
   h. Name, address and phone number of manufacturer and manufacturer's local service representative.

4. Manufacturer's Warranty

5. Provide a signed written certification report with the Final Operation and Maintenance Manuals, certifying that each motor has been properly installed, lubricated, and adjusted, and is suitable for satisfactory continuous operation under varying operating conditions, and meets all requirements specified in the Contract Documents.

1.05 QUALITY ASSURANCE

A. All motors shall be UL listed and labeled.

B. Induction motors shall be manufactured by U.S. Motors, Baldor, General Electric, or equal.
C. Motors shall be provided with an extended warranty by the manufacturer against material and workmanship defects. The extended warranty shall be the manufacturer’s standard policy, and shall be in addition to the Contractor’s Contract warranty requirements.

1. Premium efficient motors shall be warranted for 36 months.
2. Inverter duty motor shall be warranted for 36 months.
3. Severe duty motors shall be warranted for 60 months.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

All electric motors shall comply with NEMA MG 1. Motors shall be suitable for the starting method indicated on the Drawings. All motors shall be sized to carry continuously all loads which may be imposed by the driven equipment through their full range of operation.

A. Minimum Service Conditions (Unless Specified Otherwise)

Motors shall be capable of operating continuously and satisfactorily in ambient temperatures from minus 10°C (+14°F) to plus 50°C (+122°F) and at a maximum elevation of 3,300 feet.

B. Minimum Requirements

1. Motors driving identical equipment shall be identical.

2. Motor nameplate horsepower:
   a. Motors shall be sized so that the brake horsepower (BHP) requirement of the driven equipment does not exceed 90 percent of the motor full load nameplate horsepower, unless specified otherwise.
   
   b. The motor horsepower indicated on the Drawings or specified in the driven equipment specification section are based on information and estimates from the manufacturer(s) of the driven equipment. The nameplate horsepower of the supplied motor shall not be less than the motor horsepower indicated on the Drawings or specified in the driven equipment specification section.
c. If the minimum specified motor horsepower is not adequate to satisfy the sizing requirements herein or any other requirements of the Contract Documents, motors with the necessary horsepower shall be provided at no additional cost to the District. In addition, any changes to equipment and material related to an increase in motor horsepower shall be made by the Contractor at no additional cost to the District. These related changes shall include, but not be limited to, the following: circuit breakers, motor starters, motor overload devices, motor power feed conductors, and conduit sizes.

3. Motors shall be rated for continuous operation at the specified service factor and specified minimum service conditions.

4. All motors shall be NEMA Design B unless specified otherwise in the driven equipment specification section, or required by the application.

5. Motors shall be rated for full voltage across-the-line starting.

6. Starting current at full voltage shall not exceed 650 percent of the motor full load current for all integral horsepower motors.

7. The motor shall be capable of accelerating the driven machine from zero to top speed with motor power supply at 90 percent of rated voltage without overheating.

8. Motors shall be designed for high power factor. Minimum motor power factor at full load shall be 80 percent.

9. Maximum locked-rotor kVA/hp code letter shall be Code G for motors 15 hp and larger, unless specified otherwise.

10. Two-speed motors shall be two-winding motors. Two-speed, one-winding motors are not acceptable.

11. All motors shall have a safe stall (locked-rotor) time equal to or greater than the maximum accelerating time under the worst voltage conditions specified.

12. Motors shall be designed for operation in either direction of rotation without a physical change to the motor.

13. Motor fans shall be suitable for bi-directional rotation, and shall be accurately balanced before assembly on the motor.
C. Special Service Conditions

1. Motors driven by Variable Frequency Drive (VFD) systems shall comply with the following:

a. Inverter duty rated and labeled.

b. Meeting the requirements of NEMA MG 1, Part 31 including winding insulation.

c. Satisfactory for operation with standard power feed conductors (no requirements for special cables).

d. Capable of operating continuously at 10% of full speed.

e. Rotors shall be stiff shaft design, statically and dynamically balanced. First lateral critical speed shall be at least 20% above the maximum running speed of the driven equipment.

f. Compatible with the VFD system to be supplied including peak output voltage and switching frequencies.

g. Motor bearings shall be protected from shaft current produced by common mode voltages and other electromagnetic interaction of the motor and VFD.

h. 30 hp and larger motors shall be provided with a shaft grounding device (ring) on the drive end.

i. 100 hp and larger motors shall be provided with insulated bearings and a shaft grounding device.

j. Sound pressure levels shall be limited to a maximum of 10 dB greater for motors used with PWM drives than for motor operation on sine wave power at a distance of 3 feet from any motor surface.

k. Rated for a service factor of 1.0.
2. Motors located in NEC hazardous Class I, Division 1 or Class I, Division 2 areas shall be properly rated for the hazardous location classification and ignition temperatures. As a minimum, motors located in Class I, Division 1 areas shall be rated explosion-proof, and shall be UL listed and labeled. Motors shall be in compliance with the requirements of UL 674. In addition, motor winding thermostats, motor starting, and motor controls shall be in accordance with the motor manufacturer’s recommendations, and shall satisfy the requirements of the NEC and UL.

3. Motors located in wet or corrosive areas shall be rated for severe duty. As a minimum, severe duty motors shall comply with the following:

   a. Fan material shall be strong and durable, and shall be abrasion and corrosion resistant.

   b. Enclosures shall be totally enclosed fan cooled (TEFC) or totally enclosed non-ventilated (TENV). Motor case construction shall be corrosion resistant cast iron, including one-piece frame, end shrouds, conduit box, and fan shroud.

   c. External surfaces shall have a high bond heavy build double epoxy enamel finish. The finish shall provide maximum corrosion protection and withstand the effects of outdoor weathering including sunlight.

   d. All hardware shall be constructed of stainless steel.

   e. Permanent bearing isolators shall be installed on the shaft extension and fan ends.

   f. Motors shall be designed and constructed to IEEE Standard 841.

2.02 ELECTRICAL REQUIREMENTS

Unless indicated otherwise on the Drawings, or specified otherwise in the individual equipment sections of the driven equipment, motor electrical requirements shall be as follows:

A. Voltage and Frequency

1. Motors 1/2 hp through 500 hp:

   Motors shall be rated for 460 V, 3-phase, and 60 Hz power.

2. Motors smaller than 1/2 hp:
Motors shall be rated for 115/230 V, 1-phase, 60 Hz power, and shall be of the capacitor-start, induction-run type.

3. Motors shall operate successfully under running conditions at rated load with variation in the voltage or the frequency not exceeding the following conditions:
   a. +/-10% rated voltage at rated constant volts/hertz ratio, except for specific torque boost situations.
   b. +/-5% rated frequency at rated constant volts/hertz ratio.
   c. Motors shall operate successfully under running conditions at rated load and volts/hertz ratio when the voltage unbalance at the motor terminals does not exceed 1%.

B. Operating Characteristics

With rated volts/hertz ratio applied under specified service conditions, motor performance shall be as follows for critical operating characteristics:

1. Torque

   Motors shall meet or exceed the minimum locked rotor (starting) and breakdown torques specified in NEMA MG 1-12 for Design B for the rating specified when operating on sine wave power. Torque and slip characteristics shall be as recommended by the manufacturer of the driven equipment and as specified.

2. Current

   Locked rotor currents shall not exceed NEMA Design B values.

3. Efficiency

   Unless specified otherwise, all motors shall be premium efficiency in accordance with NEMA MG 1. Motor efficiency will be determined according to NEMA MG 1-12, IEEE Test Procedure 112 Method B, using accuracy improvement by segregated loss determination including stray load loss measurements.

4. Temperature Rise

   Temperature rise above the specified maximum ambient temperature, for each of the various parts of the motor, shall not exceed the values indicated in NEMA MG 1-12.
5. **Time Rating**

   All motors shall be rated for continuous duty.

C. **Service Factor**

   All motors shall be rated for a 1.15 service factor on sine wave power, unless specified otherwise. Service factor shall not be used for motor sizing.

D. **Insulation**

   1. Motors shall be designed for a Class B temperature rise, and shall be provided with Class F insulation systems per NEMA MG 1. Insulation system shall be resistant to attack from moisture, acids, alkalis, and mechanical or thermal shock. Motor insulation and related components shall be constructed of non-wicking, non-hydroscopic materials. As a minimum, motors shall be furnished with one dip and bake in 100% solids, polyester or epoxy resin.

   2. Motors constructed in NEMA frames 284 and larger, shall be provided with winding insulations that are vacuum pressure impregnated (VPI) with 100% solids, polyester or epoxy resin per approved manufacturer’s standards. As a minimum, motors shall be furnished with one VPI cycle of 100% solid resins. Motors installed outdoors shall be furnished with two VPI cycles of 100% solid resins to provide moisture-resistant windings.

   3. Where required elsewhere in the Specifications or where indicated on the Drawings, a completely encapsulated insulation system shall be provided. Stator windings and end-turns in squirrel-cage induction motors shall be completely filled with an insulating resin which shall also form a protective coating. Winding insulations shall be vacuum pressure impregnated with 100% solids, polyester or epoxy resin per approved manufacturer’s standards. Encapsulated windings shall be tested in accordance with NEMA MG 1-20.35.7.

2.03 **MECHANICAL REQUIREMENTS**

A. **Frame Sizes**

   Motor frame sizes shall be NEMA frame size designations for sizes 143 through 447. Motor frame sizes larger than NEMA frame designations shall be per approved motor manufacturers. NEMA frames shall be in accordance with NEMA MG 1.
B. **Enclosures**

1. Enclosures for induction motors shall be approved for the installation conditions, and as specified.

2. Unless specified otherwise, motor housings, motor frames, end shields, inner bearing caps, and fan covers shall be constructed of cast iron or heavy gauge fabricated steel.

3. The enclosure types shall be the following, unless specified otherwise in the individual equipment sections of the driven equipment.
   
   a. Motors installed indoors shall be Open Drip-Proof (ODP).
   
   b. Motors installed outdoors shall be ODP Weather Protected Type I, or Totally Enclosed Fan Cooled (TEFC).
   
   c. Vertical motors installed indoors and outdoors shall be ODP Weather Protected Type I.
   
   d. Motors to be installed in hazardous (classified) areas shall be provided as specified herein, and shall conform to the requirements of NEC Article 500.

4. Motors shall have drain openings suitable located for the type of enclosure and assembly being provided.

5. TEFC motors shall be furnished with tapped drain holes with stainless steel drain plugs for frames smaller than 284 and automatic breather and drain devices for frames 284 and larger. TEFC horizontal motors shall be furnished with drain holes at each end support bracket.

6. Openings on weather protected enclosures shall be covered with corrosion resistant metal guard screens have a mesh size no larger than 1/2 inch square.
C. **Windings and Winding Protection**

1. Windings shall be copper magnet wire rated at 200ºC and moisture resistant. Magnet wire insulation material shall be of the type designed to resist transient spikes, high frequencies, and short time rise pulses produced by inverters. Windings shall be firmly held in the stator slots to prevent coil shifts. Sharp edges and burs shall be removed from the stator core slots prior to inserting the winding. All coils shall be phase insulated and laced down such that the windings will not move during repetitive starting. All stator connections shall be securely made.

2. Motors 50 hp and larger shall be provided with three resistance temperature detectors (RTDs) or PTC thermistors in the windings. Any overload condition shall cause all phases to open. Motor temperature detectors shall be furnished with controllers for installation in Motor Control Centers or Motor Control Panels.

D. **Bearings**

Provide bearings that are designed for the specified conditions under continuous operation, with proportions, mountings, and adjustments consistent with best modern practices for all applied radial and thrust loads at specified speeds. Bearings shall be designed to withstand any inertial forces associated with starting and stopping of the motor. Bearings shall be anti-friction type and the bearing chamber shall be coated with a rust inhibiting grease or oil. When possible, provide end brackets with lube fill and relief plugs, which allow re-greasing while the motor is in service.

1. Bearings shall be designed to provide the following minimum L-10 bearing life:

   a. Direct connected 100,000 hours.

   b. Belt connected 50,000 hours.

Bearings and lubrication shall be suitable for the specified ambient temperature and temperature rise.

2. **Ball Bearings**

Ball bearings shall be double shielded, grease or oil lubricated. Provide lubrication from readily accessible inlet and outlet plugs or fittings. Provide bearing protection with internal shaft slingers or inner bearing caps.
3. Roller Bearings

Provide roller bearings for V-belt drive applications.

4. Oil Lubricated Bearing Housing

Furnish with adequate reservoir depth to provide space for settling of foreign matter. Provide drain plug accessible from motor exterior, and a visual oil level indicator.

5. Ball Bearing Couplings on Horizontal Motors

Construct to absorb total movement and thermal expansion of motor driven equipment shafts.

6. Sleeve Bearings

Sleeve bearings shall be furnished with proper oil rings. The use of wicks or packings are not acceptable.

7. Couplings for Sleeve Bearing Motors

Provide type to prevent motor rotating thrust surface from contacting sleeve bearing thrust collar.

8. Lubrication Fittings

Except on motors equipped with factory-sealed bearings, provide lubrication fittings with easily accessible grease/oil supply, flush, drain, relief, and extension tubes (where necessary).

E. Motor Shaft

Motor shaft shall be 1045 Hot Rolled Steel.

F. Fan Cooled

Motors specified as fan cooled shall be equipped with ventilating fans constructed of non-corroding and non-sparking materials.
2.04 ACCESSORIES AND OPTIONS

A. Grounding

Lugs shall be provided in all motor terminal boxes for grounding.

B. Terminal Boxes

1. Motors shall be equipped with terminal boxes for all conduit and wire connections, as specified and as required.

2. Gaskets shall be provided between each terminal box and motor frame, and terminal box and cover plate. Terminal boxes shall be attached to the motor frames with high strength zinc plated and chromated steel bolts and cap screws.

3. Terminal boxes for motor main power leads shall be over-sized (meeting or exceeding volumes provided in IEEE 841), diagonally split, and rotatable in 90º increments. Terminal boxes shall be provided with threaded conduit entrances.

4. A separate terminal box shall be provided for motor space heater power leads and motor winding temperature sensor wiring. Space heater leads and motor winding temperature sensor wiring shall be terminated on terminal blocks.

5. The internal temperature of motor terminal boxes shall allow use of 75ºC rated conductors.

C. Space Heaters

Space heaters shall be designed to maintain the winding temperature at 5°C above the ambient temperature when the motor is not in use. Unless specified otherwise, space heaters shall be 115 V, 1-phase, 60 Hz, and shall be thermostatically controlled.

Unless specified otherwise, space heaters shall be provided on all motors 30 hp and larger to be installed outdoors, and on all motors 50 hp and larger to be installed indoors.

Space heaters shall be unaffected by the accumulation of moisture and shall have terminals adequately protected against moisture under severe weather conditions. Space heaters shall be mounted on noncombustible material and shall be capable of operating continuously without thermal damage to the motor or themselves. Space heaters shall have a maximum sheath temperature of 200ºC.

Power leads for motor space heaters shall be brought out into a terminal box separate from the motor main power leads terminal box.
Where motors are provided with space heaters, a warning nameplate shall be provided on the motor space heater terminal box. The warning nameplate shall have red background with white letters and shall read: "CAUTION - CONTAINS AN EXTERNAL VOLTAGE SOURCE."

D. Lifting Devices

All motors weighing 150 pounds or more shall have suitable lifting devices for installation and removal.

E. Finish

Unless specified otherwise, motor castings, enclosures, terminal boxes, etc. shall be factory coated with a red-oxide zinc-chromate primer, and finished with a corrosion resistant epoxy coating. Motor field finish coatings shall be in accordance with Specification Section 09900, the Protective Coating Schedule on the Drawings, and manufacturer's written instructions.

F. Nameplates

Provide stainless steel nameplates of ample size with clear stamped or engraved numerals and letters. Motor nameplate data shall conform to NEMA MG 1 requirements, and shall include the following information, as a minimum:

1. Motor manufacturer, serial number, model number, type, frame size, enclosure type, rated horsepower, rated full load rpm, rated voltage, rated frequency, number of phases, rated full load amperes, NEMA design code, locked rotor code letter, torque, service factor, power factor, full load nominal efficiency, insulation class, maximum ambient temperature, time rating, altitude, thermal protection, space heater wattage and voltage, bearings, mounting, and other essential data.

2. Nameplate data shall be completely in English.

3. Nameplates shall be secured to the motor frame with corrosion resisting stainless steel pins in accessible locations.

G. Hardware

Unless specified otherwise, external screws and bolts shall be Grade 5, hex head and plated to resist corrosion.
H. Dynamic Balance and Vibration

1. All motors shall be dynamically balanced. Methods of measuring dynamic balance shall be in accordance with NEMA MG 1-7.

2. Motors shall have a maximum peak-to-peak amplitude of vibration in accordance with NEMA MG 1-7.8.

PART 3 - EXECUTION

3.01 FACTORY TESTS

A. All Motors Smaller than 100 hp

Motors shall be given a standard commercial test.

B. All Motors 100 hp and Larger

Motors shall be given complete tests including:

1. No load running current.

2. Locked rotor current.

3. Full load heat run.

4. High potential test.

5. Winding resistance.


7. Locked and idle saturation curves.

8. Service factor heat run.


11. Locked rotor torque.

12. Efficiency at full, 3/4, and 1/2 load.
13. Power factor at full, 3/4, and 1/2 load.

14. Balance to 0.001 inches total amplitude.

15. Noise test.

16. All tests (except locked rotor current) shall be made at full voltage and rated frequency.

3.02 DELIVERY, STORAGE, AND HANDLING

A. Contractor shall carefully inspect all motors at the time of delivery. Contractor shall notify the District in writing of any damage to the motor or motor components and accessories. Contractor shall repair or replace damaged motors to the satisfaction of the District, all at no additional cost to the District.

B. Storage and handling of motors shall be in accordance with the manufacturer’s written recommendations. Motors shall not be stored outdoors, and shall be protected from exposure to dirt, fumes, water, corrosive liquids and gases, and physical damage.

C. Contractor shall make provisions to protect motors from moisture by temporary connection of motor space heaters or installation of temporary heating equipment. Motors shall be protected against condensation until permanent motor power is provided.

D. Motor shafts shall be periodically rotated according to the manufacturer’s instructions.

3.03 INSTALLATION

A. Provide all the equipment installations and wiring installations, including connections as indicated on the Drawings, specified herein, and required.

B. Assure proper fits for all equipment and materials in the spaces shown on the Drawings.

C. Coordinate locations of all conduit stub-ups with actual locations of motor terminal boxes for power and motor auxiliary device connections.

D. General Requirements

1. Motors shall be installed in accordance with requirements of the individual driven equipment specifications, and in accordance with the manufacturer's recommendations.
2. Provide the required wiring for motor power, including installation of motor connections in accordance with the motor manufacturer’s requirements.

3. Provide the required wiring for all control equipment that shall be furnished and installed by other sections of the Specifications.

4. Provide the required wiring for heaters in the motor frames and the required controls to de-energize the heaters when the motors operate.

E. Install equipment local control stations on steel stanchions and building structures near their respective motors as shown on the Drawings.

F. Provide power, control, alarm, and grounding installations for all motors as indicated on the Drawings and required.

G. Connections of devices sensitive to electromagnetic interferences such as RTDs, thermistors, thermal protection switches, vibration sensors and other applicable instrumentation wiring shall be provided in accordance with the manufacturer’s written instructions. Shielded conductors shall be provided and routed in dedicated conduits, all in separate conduits runs end to end.

H. Align the motor shaft with driven equipment according to manufacturer’s written instructions.

I. Field damaged factory finish on equipment shall be touched-up with paint that is equal in quality and color to the original factory finish and in accordance with Specification Section 09900.

3.04 FIELD CHECKS AND TESTS

A. Field Checks

1. Check power and accessory connections for all motors.

2. Confirm correct rotation for all motors.

3. Confirm that the motor and coupled load are properly aligned, rotate freely, and are not binding.

4. Check all motors for correct clearances and proper installation of all safety guards and screens.

5. Check all motors for correct lubrication and correct any identified deficiencies in accordance with the manufacturer’s written instructions.
B. **Field Tests**

1. Contractor shall megger (1000 volts, DC) each motor winding before energizing the motor. If the insulation resistance is found to be low, Contractor shall notify the District and shall not energize the motor. Insulation resistance shall be measured after one (1) minute of megger test run, and all readings shall be recorded.

2. Operating tests shall be performed on the motor driven equipment to observe that motors start, run, and stop satisfactorily. Contractor shall submit field data to the District. The data shall indicate the full load current for each motor, and current rating for the overload relay in each motor starter and controller.

**END OF SECTION 16150**
SPECIFICATIONS - DETAILED PROVISIONS
Section 16151 - Vertical Hollowshaft Electric Motors

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PART 1 - GENERAL

1.01 SCOPE

A. This section specifies the electrical requirements for vertical hollowshaft (VHS) squirrel-cage induction motors. VHS motors shall be supplied by the manufacturer of the driven equipment as specified in this section, Specification Section 16150, and specifically outlined in the equipment sections of these Specifications. The requirements of the individual driven equipment sections are equally applicable to the work specified herein. Where conflict exists, the individual equipment sections shall take precedence.

B. Contractor shall furnish and install VHS motors, accessories, and appurtenances as specified herein, as specified in Section 16150, and in conformance with the individual specifications of driven equipment, to provide a complete and operable installation, all in accordance with the requirements of the Contract Documents.

C. The Contractor and equipment manufacturer shall be responsible for providing motors and controls sized in accordance with the requirements specified herein and in the individual equipment sections. Under no circumstances shall the nameplate rating of the motor be exceeded under the maximum design capacity of the equipment supplied. In addition, the motor service factor shall not be used for motor sizing.

1.02 SPECIFIC PROJECT REQUIREMENTS

Specific project requirements are provided in Section 11936.1, Vertical Turbine Pumps (Custom) for rated horsepower and speed. Contractor shall coordinate the base dimensions of the pump discharge head assembly and the VHS driver prior to fabrication and delivery to project site.

1.03 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Sections of the Specifications specifying VHS motor driven equipment.

2. Section 11936 - Vertical Turbine Pumps
3. Section 16010 - General Electrical Requirements
4. Section 16050 - Basic Electrical Materials and Methods
5. Section 16150 – Induction Motors
6. Section 16160 - Variable Frequency Drives
7. Section 16480 - Motor Control Centers, Switchboards, and Panelboards
8. Section 17005 - General Instrumentation and Control Components

1.04 REFERENCE STANDARDS AND CODES

All equipment and materials, including installation of same, shall meet or exceed the applicable requirements of the following standards and codes (latest edition):

A. American Bearing Manufacturer’s Association (ABMA)
   1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings
   2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings

B. Institute of Electrical and Electronics Engineers (IEEE)
   1. IEEE 43 – Recommended Practice for Testing Insulation Resistance of Rotating Machinery
   2. IEEE 85 – Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery
   3. IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators

C. National Electrical Manufacturers Association (NEMA)
   1. MG 1 - Motors and Generators
   2. MG 2 – Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators
   3. MG 13 – Frame Assignment for Alternating-Current Integral-Horsepower Induction Motors
D. National Fire Protection Association (NFPA)
   1. NFPA 70 - National Electrical Code (NEC)

1.05 SUBMITTALS

A. Contractor shall prepare and submit complete Shop Drawings as specified in Section 16150.

B. Contractor shall prepare and submit complete Operation and Maintenance Manuals as specified in Section 16150.

1.06 QUALITY ASSURANCE

A. All motors shall be UL listed and labeled.

B. VHS motors shall be manufactured by U.S. Motors, Baldor, General Electric, or equal.

C. VHS motors shall be provided with an extended warranty by the manufacturer against material and workmanship defects. The extended warranty shall be the manufacturer’s standard policy, and shall be in addition to the Contractor’s Contract warranty requirements.

1. Premium efficient motors shall be warranted for 36 months.

2. Inverter duty motor shall be warranted for 36 months.

3. Severe duty motors shall be warranted for 60 months.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

All VHS motors shall comply with NEMA MG 1. Motors shall be suitable for the starting method indicated on the Drawings. All motors shall be sized to carry continuously all loads which may be imposed by the driven equipment through their full range of operation.

A. Minimum Service Conditions (Unless Specified Otherwise)

Motors shall be capable of operating continuously and satisfactorily in ambient temperatures from minus 10°C (+14°F) to plus 50°C (+122°F) and at a maximum elevation of 3,300 feet.
B. **Minimum Requirements**

Motors shall comply with all requirements specified in Section 16150, as applicable to VHS motors, except as modified herein.

C. **Special Service Conditions**

1. Motors driven by Variable Frequency Drive (VFD) systems shall comply with the following:

   a. Inverter duty rated and labeled.

   b. Meeting the requirements of NEMA MG 1, Part 31 including winding insulation.

   c. Satisfactory for operation with standard power feed conductors (no requirements for special cables).

   d. Capable of operating continuously at 10% of full speed with variable torque.

   e. Compatible with the VFD system to be supplied including peak output voltage and switching frequencies.

   f. Motor bearings shall be protected from shaft current produced by common mode voltages and other electromagnetic interaction of the motor and VFD.

   g. 30 hp and larger motors shall be provided with a shaft grounding device (ring) on the drive end.

   h. 100 hp and larger motors shall be provided with insulated bearings and a shaft grounding device.

   i. Sound pressure levels shall be limited to a maximum of 10 dB greater for motors used with PWM drives than for motor operation on sine wave power at a distance of 3 feet from any motor surface.

   j. Rated for a service factor of 1.0.

   k. Where the driven equipment specifications require torsional calculations and analyses, VHS motor manufacturer shall provide the driven equipment manufacturer with all necessary information and data for the proposed motor.
2. Motors located in wet or corrosive areas shall be rated for severe duty. As a minimum, severe duty motors shall comply with the following:

a. Fan material shall be strong and durable, and shall be abrasion and corrosion resistant.

b. Enclosures shall be totally enclosed fan cooled (TEFC). Motor case construction shall be corrosion resistant cast iron, including one-piece frame, end shrouds, conduit box, and fan shroud.

c. External surfaces shall have a high bond heavy build double epoxy enamel finish. The finish shall provide maximum corrosion protection and withstand the effects of outdoor weathering including sunlight.

d. All hardware shall be constructed of stainless steel.

e. Permanent bearing isolators shall be installed on the shaft extension and fan ends.

f. Motors shall be designed and constructed to IEEE Standard 841.

2.02 ELECTRICAL REQUIREMENTS

Unless indicated otherwise on the Drawings, or specified otherwise in the individual equipment sections of the driven equipment, VHS motor electrical requirements shall be as follows:

A. Voltage and Frequency

1. Motors shall be rated for 460 V, 3-phase, and 60 Hz power.

2. Motors shall operate successfully under running conditions at rated load with variation in the voltage or the frequency not exceeding the following conditions:

   a. +/-10% rated voltage at rated constant volts/hertz ratio, except for specific torque boost situations.

   b. +/-5% rated frequency at rated constant volts/hertz ratio.

   c. Motors shall operate successfully under running conditions at rated load and volts/hertz ratio when the voltage unbalance at the motor terminals does not exceed 1%.
B. **Operating Characteristics**

With rated volts/hertz ratio applied under specified service conditions, motor performance shall be as follows for critical operating characteristics:

1. **Torque**

   Motors shall meet or exceed the minimum locked rotor (starting) and breakdown torques specified in NEMA MG 1-12 for Design B for the rating specified when operating on sine wave power. Torque and slip characteristics shall be as recommended by the manufacturer of the driven equipment and as specified.

2. **Current**

   Locked rotor currents shall not exceed NEMA Design B values.

3. **Efficiency**

   Unless specified otherwise, all motors shall be premium efficiency in accordance with NEMA MG 1. Motor efficiency will be determined according to NEMA MG 1-12, IEEE Test Procedure 112 Method B, using accuracy improvement by segregated loss determination including stray load loss measurements.

4. **Temperature Rise**

   Temperature rise above the specified maximum ambient temperature, for each of the various parts of the motor, shall not exceed the values indicated in NEMA MG 1-12.

5. **Time Rating**

   All motors shall be rated for continuous duty.

C. **Service Factor**

   All motors shall be rated for a 1.15 service factor on sine wave power, unless specified otherwise. Service factor shall not be used for motor sizing.
D. **Insulation**

1. Motors shall be designed for a Class B temperature rise, and shall be provided with Class F insulation systems per NEMA MG 1. Insulation system shall be resistant to attack from moisture, acids, alkalis, and mechanical or thermal shock. Motor insulation and related components shall be constructed of non-wicking, non-hydroscopic materials. As a minimum, motors shall be furnished with two dips and bakes in 100% solids, polyester or epoxy resin.

2. Motors constructed in NEMA frames 320 and larger, shall be provided with winding insulations that are vacuum pressure impregnated (VPI) with 100% solids, polyester or epoxy resin per approved manufacturer’s standards. VHS motors installed indoors shall be furnished with one VPI cycle of 100% solid resins. VHS motors installed outdoors shall be furnished with two VPI cycles of 100% solid resins to provide moisture-resistant windings.

**2.03 MECHANICAL REQUIREMENTS**

A. **Frame Sizes**

Motor frame sizes shall be NEMA frame size designations for sizes 180 through 447. Motor frame sizes larger than NEMA frame designations shall be per approved motor manufacturers. NEMA frames shall be in accordance with NEMA MG 1.

B. **Enclosures**

1. Enclosures for VHS motors shall be approved for the installation conditions, and as specified.

2. Unless specified otherwise, motor housings, motor frames, end shields, inner bearing caps, and fan covers shall be constructed of cast iron.

3. Unless specified otherwise in the individual equipment sections of the driven equipment, VHS motor enclosures shall be Open Drip-Proof (ODP) Weather Protected Type I, or Totally Enclosed Fan Cooled (TEFC).

4. Enclosures for severe duty VHS motors shall be TEFC.

5. All frames shall be provided with cast-in lifting lugs, unless cast-in lifting lugs are provided on the end shields.

6. Condensation drains shall be provided in the lowest point of the lower end shield.
C. **Windings and Winding Protection**

Windings and winding protection shall be provided as specified in Section 16150.

D. **Bearings**

1. Provide bearings that are designed for the specified conditions under continuous operation, with proportions, mountings, and adjustments consistent with best modern practices for all applied radial and thrust loads at specified speeds. Bearings and lubrication shall be suitable for the specified ambient temperature and temperature rise.

2. VHS motor bearings shall be capable of withstanding high thrust loads. VHS motor manufacturer shall design thrust bearings to carry upward or downward thrust that a pump or other driven equipment may impose during starting, shutdown, or during any other operation.

3. Unless specified otherwise, bearings shall be rated for an L-10 life of 8,800 hours (minimum).

4. **Thrust Bearings**
   a. As a minimum, VHS motors shall be provided with an angular contact thrust bearing and ball type guide bearing.
   b. Tandem angular contact thrust bearings or spherical roller type bearings shall be provided as required for extra high thrust applications.
   c. Back-to-back angular contact bearings shall be provided where required for upward thrust protection.
   d. Drive couplings shall be suitable for the thrust protection provided.

5. **Guide Bearings**
   a. Guide bearings shall be deep-groove ball type and shall be located at the bottom of the motor.
   b. Guide bearings or bearing assemblies shall be provided with sufficient means for preventing the leakage of lubricant or the entrance of foreign matter along the shaft.
6. **Lubrication**

   a. Thrust bearings shall be oil or grease lubricated. Oil lubricated bearings contained in an oil reservoir shall be provided with an oil sight level gauge and oil fill and drain openings with plugs.

   b. Guide bearings shall be grease lubricated.

   c. Grease lubricated bearings shall be provided with grease fittings and relief plugs extended to the outer periphery of the end shield to allow for in-service lubrication. Relief plugs shall be provided to protect against over lubrication.

**E. Steady Bushing**

Unless specified otherwise, each VHS motor shall be provided with a steady bushing. Steady bushings shall be constructed of SAE 660 bearing bronze (or equivalent). Steady bushings shall be designed to eliminate shaft whip and provide the mechanical stability of a vertical solid shaft motor. Steady bushing selection and installation shall be coordinated with the manufacturer of the driven equipment.

**2.04 ACCESSORIES AND OPTIONS**

VHS motors shall be furnished with accessories and options specified in Section 16150, and the following:

A. **Non-Reversing Ratchet**

   When possible, provide non-reversing ratchets for VHS motors driving pumping equipment. Contractor shall coordinate with the pumping equipment manufacturer and VHS motor manufacturer to ensure it is suitable for the pumping application. Contractor is responsible for confirming the driven assembly inertial force does not exceed the capacity of the non-reversing ratchet. If non-reversing ratchet cannot resist the torque generated from inertial forces, then the motor and driven equipment shall be capable of withstanding reverse rotation without damaging the motor or driven equipment.

   For inverter rated VHS motors operating with VFD systems, motor manufacturer shall ensure that the non-reversing ratchet will not interfere with motor operation at the minimum pumping unit speed, including causing a locked rotor or VFD tripping.
PART 3 - EXECUTION

3.01 FACTORY TESTS

A. All Motors Smaller than 100 hp

Motors shall be given a standard commercial test.

B. All Motors 100 hp and Larger

Motors shall be given complete tests including:

1. No load running current.
2. Locked rotor current.
3. Full load heat run.
4. High potential test.
5. Winding resistance.
7. Locked and idle saturation curves.
8. Service factor heat run.
11. Locked rotor torque.
12. Efficiency at full, 3/4, and 1/2 load.
13. Power factor at full, 3/4, and 1/2 load.
14. Balance to 0.001 inches total amplitude.
15. Noise test.
16. All tests (except locked rotor current) shall be made at full voltage and rated frequency.
3.02 DELIVERY, STORAGE, AND HANDLING

A. Contractor shall carefully inspect all motors at the time of delivery. Contractor shall notify the District in writing of any damage to the motor or motor components and accessories. Contractor shall repair or replace damaged motors to the satisfaction of the District, all at no additional cost to the District.

B. Storage and handling of motors shall be in accordance with the manufacturer’s written recommendations. Motors shall not be stored outdoors, and shall be protected from exposure to dirt, fumes, water, corrosive liquids and gases, and physical damage.

C. Contractor shall make provisions to protect motors from moisture by temporary connection of motor space heaters or installation of temporary heating equipment. Motors shall be protected against condensation until permanent motor power is provided.

D. Motor shafts shall be periodically rotated according to the manufacturer’s instructions.

3.03 INSTALLATION

A. Provide all the equipment installations and wiring installations, including connections as indicated on the Drawings, specified herein, and required.

B. Assure proper fits for all equipment and materials in the spaces shown on the Drawings.

C. Coordinate locations of all conduit stub-ups with actual locations of motor terminal boxes for power and motor auxiliary device connections.

D. General Requirements

1. Motors shall be installed in accordance with requirements of the individual driven equipment specifications, and in accordance with the manufacturer's recommendations.

2. Provide the required wiring for motor power, including installation of motor connections in accordance with the motor manufacturer’s requirements.

3. Provide the required wiring for all control equipment that shall be furnished and installed by other sections of the Specifications.

4. Provide the required wiring for heaters in the motor frames and the required controls to de-energize the heaters when the motors operate.
E. Install equipment local control stations on steel stanchions and building structures near their respective motors as shown on the Drawings.

F. Provide power, control, alarm, and grounding installations for all motors as indicated on the Drawings and required.

G. Connections of devices sensitive to electromagnetic interferences such as RTDs, thermistors, thermal protection switches, vibration sensors and other applicable instrumentation wiring shall be provided in accordance with the manufacturer’s written instructions. Shielded conductors shall be provided and routed in dedicated conduits, all in separate conduits runs end to end.

H. Align the motor shaft with driven equipment according to manufacturer’s written instructions.

I. Field damaged factory finish on equipment shall be touched-up with paint that is equal in quality and color to the original factory finish and in accordance with Section 09900.

3.04 FIELD CHECKS AND TESTS

A. Field Checks

1. Check power and accessory connections for all motors.

2. Confirm correct rotation for all motors.

3. Confirm that the motor and coupled load are properly aligned, rotate freely, and are not binding.

4. Check all motors for correct clearances and proper installation of all safety guards and screens.

5. Check all motors for correct lubrication and correct any identified deficiencies in accordance with the manufacturer’s written instructions.

B. Field Tests

1. Contractor shall megger (1000 volts, DC) each motor winding before energizing the motor. If the insulation resistance is found to be low, Contractor shall notify the District and shall not energize the motor. Insulation resistance shall be measured after one (1) minute of megger test run, and all readings shall be recorded.
2. Operating tests shall be performed on the motor driven equipment to observe that motors start, run, and stop satisfactorily. Contractor shall submit field data to the District. The data shall indicate the full load current for each motor, and current rating for the overload relay in each motor starter and controller.

**END OF SECTION 16151**
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PART 1 - GENERAL

1.01 SCOPE

A. This section specifies the requirements for the design, fabrication, assembly, wiring, testing, delivery, and installation of low voltage (600 volt) automatic transfer switches (ATS). Each ATS unit shall consist of a mechanically held power transfer switch and a microprocessor controller, interconnected to provide complete automatic operation.

B. Contractor shall furnish and install ATS units with the number of poles, amperage, voltage, and withstand current ratings as specified herein and shown on the Drawings.

1.02 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Sections of the Specifications specifying equipment and/or systems producing electrical power.

2. Division 16 – Electrical

3. Division 17 – Instrumentation and Controls

1.03 STANDARDS AND CODES

ATS units and accessories, including installation of same, shall meet or exceed the applicable requirements of the following standards and codes (latest edition):

A. UL 1008 - Standard for Automatic Transfer Switches

B. NFPA 70 - National Electrical Code, including use in emergency and standby systems in accordance with Articles 517, 700, 701, and 702

C. NFPA 110 – Standard for Emergency and Standby Power Systems
D. ANSI/IEEE Standard 446 - Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications

E. NEMA ICS10 (formerly ICS2-447) - AC Automatic Transfer Switch Equipment

1.04 SUBMITTALS

A. Shop Drawings

Contractor shall prepare and submit complete and organized shop drawings and product data as specified herein and in accordance with the requirements of the District's General Conditions. Shop drawings and product data shall include, but not be limited to, the following:

1. Manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, illustrations, and data in sufficient detail to demonstrate compliance with Specification requirements. Manufacturer's literature and data shall be marked to clearly delineate all applicable information and crossing out all inapplicable information.

2. Plan, elevation, side, and front view arrangement drawings, including component identification, overall dimensions, weights, clearances, conduit entrance locations, and mounting or anchoring requirements.

3. Electrical wiring diagram showing ATS normal, emergency and load connections. Electrical wiring diagram showing all controller terminal block connections. In addition, provide a summary listing of all terminal block connections, including terminal block number, function, and a brief description of each connection.

4. Manufacturer's certificate of compliance or published data reflecting a UL 1008 listing for the ATS unit(s) to be supplied.

B. Operation and Maintenance Manual

Contractor shall submit a detailed Operation and Maintenance Manual for the equipment specified herein and incorporated into the Work. The Operation and Maintenance Manual shall be provided in accordance with the requirements of the District's General Conditions, and Section 01430. Operation and maintenance manuals shall include, but not be limited to, the following:
1. Equipment Performance Data and Drawings
   a. Manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, and illustrations.
   b. As-built general arrangement drawings.
   c. As-built schematic diagrams and electrical wiring diagrams showing ATS normal, emergency and load connections, and controller input/output connections.

2. Equipment Installation Requirements
   a. Complete, detailed installation instructions for all equipment and components.

3. Equipment Operation Data
   a. Complete and detailed sequence of operation and operating instructions, including operator interface menus, programming, and setup parameters.
   b. Printed list of all final setup parameters for each ATS unit, including factory settings and any field modifications to factory settings.

4. Equipment Service and Maintenance Data
   a. Maintenance data shall include all information and instructions required by District's personnel to keep equipment properly cleaned and adjusted so that it functions correctly throughout its full design life.
   b. Unloading, handling, and long term storage requirements.
   c. Explanation with illustrations as necessary for each maintenance task.
   d. Recommended schedule of maintenance tasks.
   e. Troubleshooting instructions.
   f. List of maintenance tools and equipment.
   g. Recommended spare parts list.
h. Name, address and phone number of manufacturer and manufacturer's local service representative.

5. Manufacturer's Warranty

6. Provide a signed written certification report with the Final Operation and Maintenance Manuals, certifying that each ATS unit has been properly installed, calibrated and adjusted, and is suitable for satisfactory continuous operation under varying operating conditions, and meets all requirements specified in the Contract Documents.

1.05 QUALITY ASSURANCE

Each ATS unit shall be designed, fabricated, tested, furnished, and warrantied by a manufacturer that has been regularly engaged in the production of UL Standard 1008 listed ATSs for a minimum of 10 years, and the ATS unit to be supplied has been available on the open market for a minimum of 5 years. All ATS units shall be the product of the same manufacturer. ATS units shall be as manufactured by ASCO, Russelectric, Zenith, or equal.

The listing of specific manufacturers herein does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed herein are not relieved from meeting these specifications in their entirety; and, if necessary, they shall provide non-standard, custom equipment and/or products. Contractor shall be responsible for confirming that the proposed equipment and/or products will meet these specifications.

1.06 MANUFACTURER'S WARRANTY

Manufacturer shall guarantee all equipment against defects in material and workmanship for a period of two years from date of project acceptance. During the warranty period, manufacturer shall provide all labor and material required to repair or replace defective equipment at no cost to the District.

PART 2 – PRODUCTS

2.01 GENERAL

A. The ATS unit shall transfer load in delayed transition (break-before-make) mode. Transfer shall be accomplished with a user-defined interruption period in both directions, as specified herein. The load disconnect time delay shall be configured to be active for all transfers or to be bypassed in the event that the voltage of all three phases of the source the load is connected to drop below 70% of nominal.
B. Minimum ATS size (amperage rating) shall be as shown on the Drawings. The ATS unit shall be rated for continuous duty based on all load classes (inductive motors, resistive loads, electric discharge lamps, and tungsten lamps).

C. Each ATS unit shall be suitable for installation in an MCC section or in its own enclosure as shown on the Drawings.

D. Unless specified otherwise, ATS units shall be 3-pole and suitable for application to 3-phase, 3-wire, 60 Hz, 480 V systems.

E. ATS units shall be rated to close-on and withstand the available RMS symmetrical short circuit current at the ATS terminals with the type of overcurrent protection shown on the Drawings and selective coordination (short time/instantaneous ratings) determined by Contractor's Short Circuit/Coordination Study per Specification Section 16040.

As a minimum, ATS units shall be 3-cycle rated in accordance with UL Standard 1008. Minimum UL 3-cycle close-on and withstand ratings at 480 VAC with any molded case circuit breaker (MCCB) matching the ATS size, specific coordinated MCCBs, or current limiting fuses shall be as follows:

<table>
<thead>
<tr>
<th>ATS Size (Amps)</th>
<th>Any MCCB</th>
<th>Specific Coordinated MCCB</th>
<th>Current Limiting Fuses</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 – 200</td>
<td>30,000 A</td>
<td>42,000 A</td>
<td>200,000 A</td>
</tr>
<tr>
<td>260 – 400</td>
<td>35,000 A</td>
<td>42,000 A</td>
<td>200,000 A</td>
</tr>
<tr>
<td>600</td>
<td>42,000 A</td>
<td>50,000 A</td>
<td>200,000 A</td>
</tr>
<tr>
<td>800 – 1200</td>
<td>50,000 A</td>
<td>65,000 A</td>
<td>200,000 A</td>
</tr>
<tr>
<td>1600 – 2000</td>
<td>85,000 A</td>
<td>85,000 A</td>
<td>200,000 A</td>
</tr>
<tr>
<td>2600 - 3000</td>
<td>100,000 A</td>
<td>100,000 A</td>
<td>200,000 A</td>
</tr>
</tbody>
</table>

2.02 CONSTRUCTION

A. The ATS unit shall be electrically operated and mechanically held. The electrical operators shall be dual-solenoid or dual-motor mechanisms, momentarily energized. The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing.

B. The ATS unit contacts shall be positively locked and unaffected by momentary outages so that contact pressure is maintained at a constant value and temperature rise at the contacts is minimized for maximum reliability and operating life.

C. All main contacts shall be silver alloy composition designed to resist burning or pitting. Separate arcing contacts designed for rapid and reliable arc quenching and equipped with magnetic blowouts shall be provided.
D. Inspection of all contacts shall be possible from the front of the ATS without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to manually stop the contacts at any point throughout their entire travel to inspect and service the contacts when required.

E. Designs utilizing components which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable. Insulated case and molded-case circuit breaker type switches are not acceptable.

F. Where specified for use on 3-phase, 4-wire systems, utilizing ground fault protection, a true 4-pole switch shall be provided with all 4-poles mounted on a common shaft. The continuous current rating and the closing and withstand rating of the fourth pole shall be identical to the rating of the main poles.

G. Power connection lugs shall be screw type or compression type, suitable for 75ºC (minimum) rated copper conductors. Where neutral conductors are to be solidly connected, a fully-rated neutral terminal plate or bar with AL-CU neutral lugs shall be provided.

H. Control components and wiring shall be front accessible without disassembly of operating linkages and with disconnection of power conductors. All control wiring shall be identified with tubular sleeve-type markers.

I. Each ATS unit shall be mounted and wired at the factory, including mounting and wiring of all door-mounted accessories.

2.03 CONTROLLER

A. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance. Controller components and wiring shall be front accessible.

B. The controller shall direct the operation of the transfer switch. The controller’s sensing and logic shall be controlled by a built-in microprocessor for maximum reliability and minimum maintenance.

C. A graphical LCD or VGA display and keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and limited control through a front accessible communications port. All instructions and controller settings shall be easily accessible, readable and accomplished without the use of codes, calculations, or instruction manuals.
D. Voltage sensing shall be true RMS type and shall be accurate to ±1% of nominal voltage. Frequency sensing shall be accurate to ±0.1Hz. Time delay settings shall be accurate to ±0.5% of the full scale value of the time delay.

E. As a minimum, the ATS unit including controller shall be capable of operating over a temperature range of 0 to 40ºC.

F. The controller shall be enclosed with a protective cover and be mounted separate from the transfer switch unit for safety and ease of maintenance. Sensing and control logic shall be provided on printed circuit boards.

G. Non-automatic (manual) operation of the ATS unit shall be selectable via the controller keypad, without requiring the use of an external manual operator or opening of the enclosure door.

H. The controller shall meet or exceed the requirements for Electromagnetic Compatibility (EMC) as follows:

1. IEC 60947-6-1 Multiple Function Equipment Transfer Switching Equipment, 61000-4 Testing and Measurement Techniques – Overview
   a. IEC 61000-4-2: Electrostatic Discharge Immunity Test (Level 4)
   b. IEC 61000-4-3: Radiated RF, Electromagnetic Field Immunity Test
   c. IEC 61000-4-4: Electrical Fast Transient/Burst Immunity Test
   d. IEC 61000-4-5: Surge Immunity Test
   e. IEC 61000-4-6: Conducted RF Immunity Test

2. EN55022 (CISPR11): Conducted and Radiated Emissions, Class B
2.04 OPERATION

A. Voltage and Frequency Sensing

1. Voltage and frequency on both the normal and emergency sources (as noted below) shall be continuously monitored, with the following pickup, dropout, and trip settings capabilities (values shown as % of nominal unless otherwise specified).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Source</th>
<th>Dropout/Trip</th>
<th>Pickup/Reset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undervoltage</td>
<td>N &amp; E</td>
<td>70 to 98%</td>
<td>85 to 100%</td>
</tr>
<tr>
<td>Overvoltage</td>
<td>N &amp; E</td>
<td>102 to 115%</td>
<td>2% below trip</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>N &amp; E</td>
<td>85 to 98%</td>
<td>90 to 100%</td>
</tr>
<tr>
<td>Overfrequency</td>
<td>N &amp; E</td>
<td>102 to 110%</td>
<td>2% below trip</td>
</tr>
</tbody>
</table>

2. Repetitive accuracy of all settings shall be within 1% at +25ºC.

3. Voltage and frequency settings shall be field adjustable in 1% increments either locally with the display and keypad or remotely via serial communications port access.

4. Source status screens shall be provided for both normal and emergency to provide digital readout of voltage and frequency.

B. Time Delays

1. A time delay shall be provided to override momentary normal source outages and delay all transfer and engine starting signals, adjustable 0 to 6 seconds (minimum). It shall be possible to bypass the time delay from the controller user interface.

2. A time delay shall be provided on transfer to emergency, adjustable from 0 to 60 minutes (minimum) for controlled timing of transfer of loads to emergency. It shall be possible to bypass the time delay from the controller user interface.

3. A time delay shall be provided on retransfer to normal, adjustable 0 to 240 minutes (minimum). Time delay shall be automatically bypassed if emergency source fails and normal source is acceptable.

4. The controller shall include a timer for the delayed transition transfer operation to control the transition time from neutral to the emergency source, adjustable 0 to 6 minutes (minimum).
5. The controller shall include a timer for the delayed transition transfer operation to control the transition time from neutral to the normal source, adjustable 0 to 6 minutes (minimum).

6. A cool down time delay shall be provided on shutdown of engine generator, adjustable 0 to 60 minutes (minimum).

7. A time delay activated output signal shall also be provided to drive an external relay(s) for selective load disconnect control. The controller shall have the ability to activate an adjustable 0 to 6 minutes (minimum) time delay in any of the following modes:
   a. Prior to transfer only.
   b. Prior to and after transfer.
   c. Normal to emergency only.
   d. Emergency to normal only.
   e. Normal to emergency and emergency to normal.
   f. All transfer conditions or only when both sources are available.

8. All adjustable time delays shall be field adjustable without the use of special tools.

2.05 ADDITIONAL FEATURES

A. The user interface shall be provided with keys for the test/reset modes. The test mode shall simulate a normal source failure. The reset mode shall bypass the time delays on either transfer to emergency or retransfer to normal.

B. A set of contacts rated 5 A, 30 VDC shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.

C. Auxiliary contacts, rated 10 A, 250 VAC, shall be provided consisting of:

1. One (1) normally closed dry contact, which shall open when the normal power source fails for "power failure" signal to RTU or controls as shown on the Drawings.
2. One (1) normally open dry contact, which shall close when the ATS is connected to the emergency source for "emergency power" signal to RTU or controls as shown on the Drawings.

D. LED indicating lights shall be provided; one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red).

E. LED indicating lights shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal (green) and emergency (red) source, as determined by the voltage sensing trip and reset settings for each source.

F. LED indicating light shall be provided to indicate switch not in automatic mode (manual); and blinking (amber) to indicate transfer inhibit.

G. LED indicating light shall be provided to indicate any alarm condition or active time delay (red).

H. An engine generator exercising timer shall be provided to configure weekly and bi-weekly automatic testing of an engine generator set with or without load. It shall be capable of being configured to indicate a day of the week, and time weekly testing should occur.

I. The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller which may be preventing load transfer commands from being completed.

J. Unless specified otherwise, ATS units installed outdoors shall be provided with strip heaters to prevent condensation and freezing of condensation. Unless indicated otherwise on the Drawings, strip heaters shall be provided with thermostats and shall be connected to the load terminals of the ATS for power.

**PART 3 - EXECUTION**

**3.01 FACTORY TESTING**

A. The complete ATS unit shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency, and time delay settings are in compliance with the specification requirements and the manufacturer's recommendations.

B. The manufacturer shall provide three (3) certified copies of factory test reports to District for approval prior to shipment.
3.02 INSTALLATION

A. Contractor shall install all equipment in accordance with the manufacturer’s written instructions, NEC standards, requirements and standards specified herein, and as shown on the Drawings.

B. Where an ATS unit is provided in an MCC or switchboard, Contractor shall anchor MCCs and switchboards in accordance with specified requirements for same. Where an ATS unit is provided in a separate free standing enclosure, Contractor shall anchor the enclosure to a reinforced concrete pad and floor slab in accordance with the calculations and details prepared by the manufacturer's engineer. Anchor bolt embedment depth shall be based on the thickness of the structure slab only, and shall not include any portion of the raised concrete housekeeping pad beneath the equipment. Where an ATS unit is provided in a separate wall mounted enclosure, Contractor shall anchor the enclosure to a concrete or masonry wall in accordance with the calculations and details prepared by the manufacturer's engineer.

C. Verify the compatibility of conductor size, type, and stranding versus the power lugs furnished. Utilize correct lugs in all applications. Crimp compression lugs with manufacturer recommended tools.

D. Tighten all lugs, connectors, terminals, etc. in accordance with the equipment manufacturer's published torque tightening values for same.

E. Install arc flash hazard labels in accordance with the requirements of Specification Section 16040.

F. Perform all pre-energizing checks as recommended by the manufacturer.

3.03 FIELD QUALITY CONTROL

A. Contractor shall provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in installation and start-up of the equipment specified under this Section. The manufacturer's representative shall provide technical direction and assistance to the Contractor in equipment connections and adjustments, and testing of the assembly and components contained therein.

B. The following minimum work shall be performed by the Contractor under the technical direction of the manufacturer's service representative.

1. Perform insulation tests on each power phase (and neutral where provided) and verify low resistance ground connection on ground bus.
2. Connect all power wiring and control wiring and verify basic operation of external control and status signals.

3. Torque all bolted connections made in the field and verify all factory bolted connections.

4. Perform pre-startup of the ATS controller. Calibrate any solid-state metering or control relays for their intended purpose and make written notations of adjustments on record drawings.

3.04 FIELD ADJUSTMENTS AND TESTING

A. Follow the manufacturer's instructions and the Contract Documents concerning operating transfer times, voltage and frequency settings, time delay settings, and startup of components.

B. Follow the minimum requirements as stipulated in the NETA testing procedure for ATS assemblies.

C. Prepare a field report on tests performed, test values recorded, adjustments, etc., and provide same to District for review and approval.

3.05 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer's recommendations. Equipment shall be inspected prior to the generation of any reports.

B. Manufacturer's written certification shall be provided in accordance with Detailed Provision Section 16010.

3.06 CLEANUP

A. All parts of the electrical equipment and materials shall be left in a clean condition. Exposed parts shall be clean of dust, dirt, cement, plaster and other materials, and all oil and grease spots shall be removed with a non-flammable cleaning solvent. Such surfaces shall be carefully wiped and cleaned. Paint touch-up shall be applied to all scratches on panels and cabinets. Electrical cabinets or enclosures shall be free of spider webs.

B. Paint touch-up matching factory color and finish shall be applied to all scratches on panels and cabinets.
3.07 INSTRUCTION

After the equipment has been installed, tested, and adjusted, and placed in satisfactory operating condition, the equipment manufacturer shall provide classroom instruction to District's personnel in the use and maintenance of the equipment. Two (2) hours of instruction shall be provided, unless otherwise specified. Contractor shall give the District formal written notice of the proposed instruction period at least two weeks prior to commencement of the instruction period. Scheduled training shall be at a time acceptable to the District and the manufacturer. During this instruction period, the manufacturer shall answer any questions from District personnel. The manufacturer's obligation shall be considered ended when he and the District agree that no further instruction is needed.

END OF SECTION 16250
SPECIFICATIONS - DETAILED PROVISIONS
Section 16480 - Motor Control Centers, Switchboards, and Panelboards

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PART 1 - GENERAL

1.01 SCOPE

A. This section specifies the requirements for the design, fabrication, assembly, wiring, testing, delivery, and installation of low voltage (600 volt) motor control centers (MCCs), switchboards, and panelboards. Switchboards shall include utility service switchboards and distribution switchboards.

B. Contractor shall furnish and install MCCs, utility service switchboards, distribution switchboards, and panelboards as specified herein and indicated on the Drawings.

1.02 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Sections of the Specifications specifying equipment and/or systems requiring electrical power and control.

2. Division 16 – Electrical

3. Division 17 – Instrumentation and Controls

1.03 REFERENCE STANDARDS, SPECIFICATIONS, AND CODES

A. Equipment and materials shall meet or exceed the applicable requirements of the following standards, specifications, and codes (latest edition):

Underwriters Laboratories (UL)

UL 44 Standard for Thermoset-Insulated Wires and Cables

UL 50 Standard for Enclosures for Electrical Equipment, Non-environmental Considerations
### MCCs, Switchboards, and Panelboards

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### National Electrical Manufacturers Association (NEMA)

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NEMA KS 1  Heavy Duty Enclosed and Dead-Front Switches
NEMA PB 1  Panelboards
NEMA PB 1.1  General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts, or Less
NEMA PB 2  Deadfront Distribution Switchboards
NEMA PB 2.1  Proper Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts, or Less
NEMA ST 1  Specialty Transformers (Except General Purpose Type)
NEMA ST 20  Standard for Dry-Type Transformers for General Applications
NEMA TP 1  Standard for the Labeling of Distribution Transformer Efficiency
NEMA TP 2  Standard Test Method for Measuring the Energy Consumption of Distribution Transformers

National Fire Protection Association (NFPA)
NFPA 70  National Electrical Code
NFPA 70E  Standard for Electrical Safety in the Workplace

B. Equipment shall bear the appropriate labels and markings in accordance with above standards, specifications and codes. Equipment shall be designed, manufactured, and tested in certified International Organization for Standardization (ISO) 9001 facilities.

1.04 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A. Shop Drawings

Contractor shall prepare and submit complete and organized information, drawings, and technical data for all equipment and components. All drawings shall be legible and reduced to a maximum size of 11” x 17” for inclusion within the submittal. Shop drawings shall include, but not be limited to, the following:
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1. Manufacturer’s product literature and specifications for all major components including, but not limited to, the following: circuit breakers and fuse information (including time current characteristics), motor starters, overload relays, control power transformers, pilot devices, relays, timers, fans, heaters, thermostats. Product literature and specifications shall be marked to clearly identify all applicable information and crossing out all inapplicable information. Sufficient data and detail shall be provided to demonstrate compliance with these specifications.

2. Drawings showing structure elevation and plan views with dimensional information, including, but not limited to: structure height and depth, section widths, location of shipping splits, required bus splices, conduit stub up locations, and anchorage holes.

3. Single line diagrams and schematic wiring diagrams for each structure. Schematic wiring diagrams shall clearly identify internal and external devices, and all remote contacts and signals.

4. Structure descriptions with the following: bus ratings, enclosure ratings, short-circuit withstand rating, and other information to demonstrate compliance with Contract Document requirements.

5. Component schedule, including, but not limited to: circuit breakers, disconnect switches, motor circuit protectors, and motor starters.

6. Drawings showing proposed control unit layouts for each different unit configuration with the location of all control pilot devices clearly shown (control station plate or control unit door). Each pilot device shall be clearly labeled on the drawings.

7. Unit descriptions including information such as, starter sizes, circuit breaker frame sizes, circuit-breaker continuous amperage ratings and interrupting ratings, and all proposed options/accessories.

8. Terminal size ranges for all cable connections (line and load sides).

9. Nameplate schedule for all structures and sections.

10. Short-circuit and Protective Device Evaluation Study, Protective Device Coordination Study, and Arc-Flash Hazard Study per Section 16040.

11. Utility company’s written approval of electrical service equipment drawings.
12. Design calculations and details for equipment seismic design and restraint. Calculations and anchorage details shall be prepared and stamped by a Registered Professional Civil or Structural Engineer in the State of California. Equipment seismic design and restraint calculations shall be provided for all motor control centers and switchboards. Calculations shall include anchor bolt type, size, locations, and embedment depth. Anchor bolt embedment depth shall be based on the thickness of the structure floor slab only, and shall not include any portion of the raised concrete housekeeping pad beneath the equipment structures. Calculations shall be performed in accordance with the California Building Code (latest edition) for Occupancy Category IV, Essential Facilities.

13. Manufacturer’s installation instructions, including:
   a. Receiving, handling, and storage instructions.
   b. General information for nameplate data, serial numbers, UL markings, and short-circuit ratings.
   c. Installation procedures including seismic requirements, splicing procedures, and bus torque specifications.
   d. Conduit and cable installation.
   e. Grounding requirements.
   f. Installing and removing plug-in units.
   g. Arc-flash protection labeling.
   h. Operation of operator handles and unit interlocks.
   i. Checklists before energizing.
   j. Procedures for energizing equipment.

B. Operation and Maintenance Manuals

Contractor shall submit a detailed Operation and Maintenance Manual for the equipment specified herein and incorporated into the Work. The Operation and Maintenance Manual shall be provided in accordance with the requirements of the District's General Conditions, and Section 01430.
Operation and maintenance manuals shall include, but not be limited to, the following:

1. Installation instructions, as specified herein.
2. Safety precautions, including protective equipment and clothing.
3. Pre-energizing and energizing procedures for MCCs, switchboards, and panelboards.
4. Maintenance procedures, including: inspection and cleaning, servicing, disconnect switch and contact lubrication, and testing.
5. Maintenance procedures after a fault condition.
6. Troubleshooting procedures.
7. Technical data and illustrations.
8. Replacement parts list.
9. Manufacturer warranties.
10. Contact Information, including name, address, and telephone number of manufacturer and manufacturer’s local service representative.

1.05 DESIGN REQUIREMENTS

A. Provide equipment conforming to the requirements of NFPA 70, unless more stringent requirements are specified herein or indicated on the Drawings. NEMA rated and UL listed equipment is specified, and shall be provided when available. Equipment shall meet NEMA and UL construction and rating requirements as specified. No equivalent will be acceptable. Immediately notify the District of any requirements of the specifications or Contractor proposed materials or assemblies that do not comply with UL or NEMA. International Electrotechnical Commission (IEC) rated equipment will not be considered an acceptable alternative to specified NEMA ratings.

B. Equipment, conduit, and wiring sizes indicated on the Drawings, including motor sizes and associated electrical equipment ratings, are minimum requirements. Contractor shall verify all actual equipment and motor full-load and locked rotor current ratings. Contractor shall coordinate the actual current rating of equipment furnished with the size of the branch circuit conductors, motor controller, motor overload relay, and branch circuit overcurrent protection.
The branch circuit conductors shall have a carrying capacity of not less than 125% of the actual motor full-load current rating. The size of the branch circuit conductors shall be such that the voltage drop from the overcurrent protection devices up to the equipment shall not be greater than 2% when the equipment is running at full load and rated voltage. Conductor ampacities shall be derated in accordance with NEC, Table 310-16 for ambient temperatures of 114 to 122°F.

The motor running overcurrent protection devices shall be ambient temperature compensated for temperatures up to 50°C and be rated or selected to trip at no more than 125% of the motor full-load current rating for motors marked to have a temperature rise not over Class B above 50°C ambient or motors marked with a service factor not less than 1.15, and at no more than 115% for all other types of motors.

The motor branch circuit overcurrent protection device shall trip open in 10 seconds or less on locked-rotor current of the motor. This device shall also protect the motor branch circuit conductors and the motor controller against overcurrent due to short-circuits or grounds. The motor control circuits shall have overcurrent protection of the type indicated on the Drawings and specified herein.

Contractor shall make the necessary adjustments to wiring, conduit, motor controllers, disconnects, branch circuit protection, and other affected material or equipment to accommodate the motors actually furnished, all at no additional cost to the District.

C. Contractor shall verify that proposed equipment will fit into the available space for same. Prior to equipment fabrication, Contractor shall notify the District of any potential interferences or conflicts between the proposed equipment and corresponding installation locations, including associated conduit and conductors.

1.06 ARC-FLASH LIMIT

A. Contractor shall provide an Arc-Flash Hazard Study per Section 16040 to determine potential arc-flash incident energies, arc-flash boundaries, shock hazard boundaries; required personal protective equipment (PPE) for all energized electrical equipment; and arc-flash and shock hazard warning labels.

B. Unless specified otherwise, the study shall include all switchboard, emergency power transfer switch, MCC, and panelboard electrical circuits from the electric utility power source(s) and emergency power source(s) to and including all electrical equipment and panelboards rated 208 V and greater.
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C. Wherever possible, the proposed electrical equipment, including MCCs, switchboards, and panelboards, shall be designed, manufactured, and supplied to limit the potential arc-flash incident energy to 8 cal/sq cm or less (PPE Category 2). The firm performing the studies shall coordinate with Contractor, the District, and the electrical equipment manufacturers to assist in achieving this requirement.

D. Arc-flash and shock hazard warning labels shall be provided for MCCs, switchboards, and panelboards per Section 16040. Where the main protective device is specified to be equipped with an arc-flash reduction maintenance system, all MCCs, switchboards, and panelboards shall be provided with two (2) sets of labels. One (1) set shall be provided for the normal operating mode and one (1) set shall be provided for the arc-flash reduction maintenance system operating mode.

1.07 COORDINATION

A. The general arrangement of the MCCs, switchboards, and panelboards is shown on the Contract Drawings. Any modifications of the equipment arrangement or device requirements as indicated on the Drawings shall be subject to District approval. If any conflicts occur necessitating a departure from the Drawings, a written explanation and details for said departure shall be submitted and approved by the District prior to implementing any change. All equipment shall be completely factory assembled. The MCCs and switchboards may be disassembled into sections, if necessary, for convenience of handling, shipping, and installation.

B. Where project requirements include construction of a new electrical service or upgrading an existing electrical service, Contractor shall coordinate all required work with Southern California Edison (SCE) and the District. All electrical service equipment and material shall be in strict accordance with SCE requirements. Prior to commencing construction of electrical service facilities, Contractor shall submit shop drawings of proposed electrical service equipment and material to SCE and District for review and approval.

1.08 QUALITY ASSURANCE

A. The District believes that the manufacturers listed herein are capable of producing equipment and/or products that will satisfy the requirements of these specifications. The listing of specific manufacturers herein does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed herein are not relieved from meeting these specifications in their entirety; and, if necessary, they shall provide non-standard, custom equipment and/or products. Contractor shall be responsible for confirming that the proposed equipment and/or products will meet these specifications.
B. Model numbers supplied herein are provided for information purposes only, to assist Contractor in selecting equipment that conforms to the Specification and Drawing requirements. In case of any conflict between model numbers provided and the descriptive requirements specified herein, the descriptive requirements shall govern.

PART 2 - MATERIALS

2.01 MOTOR CONTROL CENTERS

A. General

MCCs shall be 600 V class suitable for operation on a three-phase, 480 V, 60 Hz system. MCCs shall be configured for 3-wire or 4-wire systems, as indicated on the Drawings. MCCs shall be manufactured by Eaton/Cutler-Hammer, Schneider Electric/Square D, Allen Bradley, or General Electric (no substitutes).

B. Structures

1. Structures shall be totally enclosed, dead-front, free-standing assemblies. Structures shall be capable of being bolted together to form a single assembly.

2. The overall height of MCCs shall be 90 inches (nominal), not including base channels, lifting angles, baffles, or plenums. Structures shall contain horizontal wireways at the top and bottom of each section. A minimum of 72 inches of vertical compartments shall be available for mounting of control units, protective devices, transformers, lighting panelboards, etc.

3. For shipment and installation, each MCC shall be provided with rigid removable or non-removable base channels enclosing all four-sides of the equipment, and removable lifting angles. Non-removable base channels shall be provided with welded closing plates at the open ends the channels.

4. The total width of one section shall be 20 inches; widths of 25 inches, 30 inches, or 35 inches shall be provided where required for larger devices or where indicated on the Drawings.

5. The minimum depth of the MCC shall be 20 inches.

6. Each 20 inch wide standard section shall be provided with all the necessary hardware and bussing for modular plug-on units to be installed. All unused space shall be covered by hinged blank doors and equipped to accept future units. Vertical bus openings shall be covered by manual bus shutters.
7. Each section shall include a top plate (single piece or two-piece). Top plates shall be removable for ease in cutting conduit entry openings.

8. MCC Structures Located Indoors

Unless indicated otherwise on the Drawings, MCC structures located indoors shall be provided with NEMA Type 1A (gasketed general purpose) enclosures.

9. MCC Structures Located Outdoors

Unless indicated otherwise on the Drawings, MCC structures located outdoors shall be provided with NEMA Type 3R, non-walk-in (rainproof) enclosures. MCC NEMA Type 3R, non-walk-in enclosures shall be based on NEMA Type 1A enclosures with a NEMA 3R wrapper. The additional housing and gasketing supplied by the NEMA 3R wrapper shall provide protection from rain, sleet, and ice. As a minimum, MCC NEMA Type 3R, non-walk-in enclosures shall comply with the following requirements:

a. The enclosing NEMA 3R wrapper shall be constructed of 12 gauge galvanneal steel with a flat or sloped roof line. Sloped roof lines shall be sloped from front to rear at a minimum of 1/2 inch per foot. Doors constructed of 14 gauge steel are acceptable if the doors are provided with suitable welded-in stiffening pans to prevent deflection. Doors constructed of 14 gauge steel without stiffening pans are not acceptable. Gasketing shall be provided all around door closing flanges (four sides).

b. Each NEMA 3R wrapper split or section shall have a minimum of 29 inches working clearance from hinge flange to door closure flange or hinge to hinge with double doors. The width of open unobstructed area when door(s) are open shall be 29 inches minimum.

c. NEMA 3R wrapper splits shall be coordinated with the MCC section splits. Cabinet spacers shall be provided at MCC section splits to permit full opening (90 degrees, minimum) of all MCC doors without interfering with the NEMA 3R wrapper doors. MCC shall be provided with all cabinet spacers, wireway extensions, horizontal bus splice kits, and ground bus splice kits required to interconnect MCC sections and provide the necessary separation for MCC doors to fully open. All MCC cabinet connections shall be provided with gaskets to maintain the specified NEMA 1 gasketed rating.

d. The rear access covers shall be flanged on four sides, and gasketed. One piece flat or multi-piece flat lipped covers are not acceptable.
e. The distance in front of a NEMA 1A MCC section to the inside of the outer NEMA 3R wrapper door(s) shall be 11 inches, minimum.

f. Lighting shall be provided using LED lighting fixtures, single-tube, with length as necessary for width of NEMA 3R wrapper split. A light switch shall be provided on side extension for each MCC shipping split, and shall be furnished with a stainless steel cover plate.

g. Convenience receptacles shall be provided for each MCC shipping split. Receptacles shall be duplex GFCI type, with stainless steel cover.

h. Control power transformers with primary and secondary fuse protection shall be provided to supply power to the NEMA 3R wrapper interior lighting and convenience receptacles, unless indicated otherwise on the Drawings. Supply voltage shall be 120 volts, 60 Hz. The control power transformers shall be prewired at the factory to all lights and receptacles.

i. Where required for MCC ventilation, NEMA 3R wrapper doors shall be provided with louvered or hooded ventilation openings at the top and bottom. Louvered openings shall be integrally molded into the doors and covered by interior mounted air filters. Hooded openings shall be clear door openings covered by exterior weatherproof hoods and interior mounted air filters. Each weatherproof hood shall be provided with a removable insect screen at the bottom. Air filters shall be washable aluminum mesh type, gasketed on all sides, and removable (without the use of tools) for cleaning.

j. NEMA 3R wrapper front door handles shall have provisions for padlocking and shall be equipped with wind stops.

k. Both MCCs and Switchboards (if applicable) shall have the same NEMA 3R wrapper design and appearance, and shall be UL approved.

C. Materials

1. Steel material shall comply with UL 845 requirements.

2. Each MCC shall consist of one or more vertical sections of heavy gauge steel bolted together to form a rigid, free-standing assembly. Vertical sections shall be made of welded side-frame assemblies formed from a minimum of 12 gauge steel. Internal reinforcement structural parts shall be of 12 and 14 gauge steel to provide a strong, rigid assembly. The entire assembly shall be constructed and packaged to withstand normal stresses included in transit and during installation.
D. **MCC Finish**

1. All steel parts shall be provided with UL listed acrylic/alkyd baked enamel paint finish or TGIC Powder Coat, except plated parts used for ground connections. All painted parts shall undergo a multi-stage treatment process, followed by the finishing paint coat.

2. Pre-treatment shall include:
   a. Hot alkaline cleaner to remove grease and oil.
   b. Iron phosphate treatment to improve adhesion and corrosion resistance.

3. The paint shall be applied using an electro-deposition process to ensure a uniform paint coat with high adhesion.

4. The standard paint finish shall be tested to UL 50 per ASTM B117 (5% ASTM Salt Spray) with no greater than 0.125 inch loss of paint from a scribed line.

5. Paint color for MCC NEMA 1 enclosures shall be #49 medium light gray per ANSI Standard Z55.1 (60-70 gloss) on all exterior surfaces, unless specified otherwise. Control station plates and escutcheon plates shall be painted a contrasting gray. All unit interior surfaces shall be painted white for better visibility inside the unit, except for unit handle mechanism side plates.

6. Paint color for MCC NEMA 3R enclosures (NEMA 3R wrappers) shall be white (60-70 gloss) on all surfaces unless specified otherwise.

E. **Wireways**

1. **Horizontal Wireways**
   a. Wireways shall be located at the top and bottom of the MCC.
   b. Wireways shall be a minimum of 6 inches in height and shall extend the full depth of the vertical sections to allow maximum flexibility in locating conduit and routing field wiring for the MCC. Where indicated on the Drawings, pull boxes shall be provided to extend the height of the top horizontal wireway by 12 inches.
   c. Wireways shall be continuous across the length of the MCC, except where access needs to be restricted for horizontal isolation requirements.
d. Wireways shall be isolated from the power buses.

e. Wireways shall have removable covers held in place by captive screws.

2. Vertical Wireways

a. A full height vertical wireway, independent of the plug-in units, shall be provided in each standard vertical section.

b. Wireways shall be isolated from the vertical and horizontal buses.

c. Isolation shall be provided between the wireway and unit compartments.

d. Wireway tie bars shall be provided in each section.

e. Wireways shall be covered with hinged and secured access doors. Access to the wireways shall not require opening control unit doors.

F. Barriers

1. All power bussing and splice connections shall be isolated from the unit compartments and the wireways. The horizontal bus shall be mounted onto a glass filled polyester support assembly that braces the bus against the forces generated during a short-circuit. The horizontal bus shall be isolated from the top horizontal wireway by a rigid non-conductive barrier.

2. Isolation of the vertical bus compartment from the unit compartment shall be by means of a full height insulating barrier. Vertical bussing shall be provided with a glass-filled polyester barrier that provides bus insulation and braces the bus against the forces generated during a short-circuit. These barriers shall have openings at a maximum spacing of 6 inches for unit stab-on connections. Openings shall be provided with manual or automatic shutters to close-off the stab openings when plug-in units are removed. Manual covers shall be attached to the structure so that when they are removed (to allow a stab connection) they are retained in the structure and are readily accessible for use should a plug-in unit be removed from the MCC.
G. **Busing**

1. The main horizontal busing shall be tin-plated copper and shall be rated at the amperage indicated on the Drawings; however, the bus shall have a minimum ampere rating of 600 A. The vertical bus connecting an incoming power feeder cable to the horizontal bus shall have the same ampere rating as the main horizontal bus. Unless specified otherwise, horizontal bus bars shall extend the length of the MCC. Bus ratings shall be continuous and shall be based on a 65°C maximum temperature rise over a 40°C ambient temperature in compliance with UL standards. The main bus shall be isolated from the horizontal wireways, and all bus connections shall be front-accessible for ease of maintenance. Provisions shall be provided for splicing additional sections onto either end of the MCC.

2. Vertical busing feeding unit compartments shall be tin-plated copper and shall be securely bolted to the horizontal main busing. The vertical busing shall be rated at the amperage indicated on the Drawings; however, the busing shall have a minimum effective ampere rating of 600 A. If center horizontal bus construction is utilized, then the rating shall be 300 A above and below the horizontal bus for an effective rating of 600 A. If a top or bottom mounted horizontal bus is utilized, the full vertical bus shall be rated for 600 A. The vertical buses shall be continuously braced by a high strength, non-conductive, non-tracking, glass-filled polyester material and isolated from the unit compartments by a non-conductive, polycarbonate molded cover. The vertical power bus shall be isolated from the horizontal power bus, except where necessary to connect the vertical bus to the horizontal bus.

3. Unit power stabs for engaging the power bus shall be tin-plated copper and shall be provided with stainless back-up springs to provide and maintain a high pressure connection to the vertical busing. Power cable terminations at the plug-in stabs shall be maintenance-free compression type connections.

4. A tin-plated copper ground bus shall be provided that runs the entire length of the MCC. The ground bus shall be a minimum of 0.25 inch x 2.0 inch and be rated for 600 A (minimum). A mechanical lug shall be provided at each end of the MCC for connecting #1/0 AWG to 250 kcmil external ground cables. The ground bus shall be provided with a minimum of six (6) 3/8 inch diameter holes for each vertical section to accept Contractor-supplied ground lugs for any loads requiring a ground conductor.

5. Each vertical section shall be provided with a copper vertical ground bus that is solidly connected to the horizontal ground bus. This vertical ground bus shall be installed so that the plug-in units engage the ground bus prior to engagement of the power stabs and shall disengage only after the power stabs are disconnected upon removal of the plug-in unit.
6. The horizontal and vertical busing shall be mounted on supports constructed of materials having high dielectric strength, high impact strength, and low moisture absorbency.

7. The system shall be rated for an available short-circuit capacity of not less than 65,000 RMS amperes in accordance with NEMA standards. If the results of the Contractor’s Electrical Short-circuit and Protective Device Evaluation and Coordination Study, as accepted by the District, indicate that a higher short-circuit duty rating of the MCC is required, Contractor shall furnish the MCC with that higher rating.

H. Disconnects

1. Main Lug Compartment (if indicated on the Drawings)
   a. If no overcurrent protection is indicated on the Drawings for incoming power, MCC shall be provided with a main incoming-line lug compartment.
   b. Lug connections shall be located at the back of the enclosure to reduce the potential hazard of contacting the lugs when opening the compartment door.
   c. Lugs shall accommodate the incoming power conductors as indicated on the Drawings. Lugs shall be provided by the MCC manufacturer.

2. Main Circuit Breaker Disconnect (if indicated on the Drawings)
   a. Lugs to accommodate the incoming power conductors as indicated on the Drawings shall be provided by the MCC manufacturer.
   b. Circuit breaker frame and trip rating shall be as indicated on the Drawings.
   c. The interrupting capacity rating shall meet or exceed the main bus rating of the MCC.
   d. The main circuit breaker shall be a molded case circuit breaker with solid-state trip unit or insulated case power circuit breaker per Part 2.04 herein.
   e. Provide a removable protective barrier to reduce the possibility of contact with the line terminals.
f. Where specified on the Drawings, provide one normally open and one normally closed circuit breaker auxiliary contact that follows the position of the circuit breaker main contacts for indication of ‘On’ or ‘Off/Tripped’.

3. Feeder Disconnects and Transformer Disconnects

a. The disconnecting means for feeders and transformers shall be molded case circuit breakers per Part 2.04 herein.

b. The interrupting capacity rating shall meet or exceed the main bus rating of the MCC.

c. Circuit breaker frame and trip rating shall be as indicated on the Drawings.

4. Motor Starter Disconnects

a. Combination Full-Voltage Starters:

i. The disconnecting means for combination full-voltage starters (across-the-line starters) shall be motor circuit protectors. Motor circuit protectors shall be provided per Part 2.01K herein.

ii. The short-circuit rating of the motor circuit protector shall be greater than or equal to the MCC main bus rating.

b. Solid-State Controllers (Solid-State Reduced Voltage Motor Controllers) and Variable Frequency Drives

i. The disconnecting means for a solid-state controller or a variable frequency drive shall be a molded case circuit breaker.

ii. The short-circuit rating of the circuit breaker shall be greater than or equal to the MCC main bus rating.

I. Typical Motor Control Unit Construction

1. Units with circuit breaker disconnects through 400 A frame, and fusible switch disconnects through 400 A, shall connect to the vertical bus through a spring reinforced stab-on connector. Units with larger disconnects shall be connected directly to the main horizontal bus with appropriately sized cable or riser bus.

2. All conducting parts on the line side of the unit disconnect shall be shrouded by a suitable insulating material to prevent accidental contact with those parts.
3. Unit mounting shelves shall include hanger brackets to support the unit weight during installation and removal. All plug-in units shall use a twin-handle camming lever located at the top of the bucket to rack in and out the plug-in unit. The cam lever shall work in conjunction with the hanger brackets to ensure positive stab alignment.

4. A lever handle operator must be provided on each disconnect. With the unit stabs engaged onto the vertical bus and the unit door closed, the handle mechanism shall allow complete "On/Off" control of the unit. All circuit breaker operators shall include a separate "Tripped" position to clearly indicate a circuit breaker trip condition. It shall be possible to reset a tripped circuit breaker without opening the control unit door. Clear indication of disconnect status shall be provided by the following operator handle positions:

   a. Handle "On" position shall be up or to the left and within 45 degrees of being parallel to the face of the equipment.

   b. Handle "Off" position shall be down or to the right and within 45 degrees of being parallel to the face of the equipment.

   c. The minimum separation between the "On" and "Off" positions shall be 90 degrees.

   d. On circuit breaker disconnects, the handle "Tripped" position shall be perpendicular to the face of the equipment +/- 30 degrees. Minimum separation between "On" and "Tripped" shall be 30 degrees. Minimum separation between "Tripped" and "Off" shall be 45 degrees.

5. A mechanical interlock shall prevent an operator from opening the unit door when the disconnect is in the "On" position. Another mechanical interlock shall prevent an operator from placing the disconnect in the "On" position while the unit door is open. It shall be possible for authorized personnel to defeat these interlocks.

6. A non-defeatable interlock shall be provided to prevent installing or removing a plug-in unit unless the disconnect is in the "Off" position.

7. The plug-in unit shall have a grounded stab-on connector which engages the vertical ground bus prior to, and releases after, the power bus stab-on connectors.

8. Provisions shall be provided for locking all disconnects in the "Off" position with up to three padlocks.
9. Unit construction shall combine with the vertical wireway isolation barrier to provide a fully compartmentalized design.

10. Unit interior surfaces (back, sides and bottom plates) shall be painted white, except for handle mechanism side plates.

J. Wiring and Terminations

1. Wherever possible, copper compression type lugs shall be provided for all line and load terminations, and shall be suitable for copper cable rated for 75°C of the size as indicated on the Drawings.

2. Copper compression type lugs shall be provided for all grounding conductor terminations to the ground bus.

3. Unless indicated otherwise on the Drawings, MCC wiring shall be NEMA Class II, Type B, with wiring schematics showing field devices and connections.

4. Where fine stranded conductors, Class C and higher (such as DLO cable) are utilized for internal wiring, all terminations in mechanical lugs shall be provided with copper flex-cable compression adapters to properly confine the fine strands and prevent overheating of the connection and wire pullout from lugs. The flex-cable compression adapters shall fit mechanical set-screw mechanical lug type connectors and shall be sized for the full current carrying capacity of the cable. The adapters shall be provided a flared barrel-opening to allow easy cable insertion. The adapter shall be constructed of wrought copper with pin of Class B stranded copper conductor, rated for 600V and 105°C cable, and shall be UL listed. Pin length shall be sufficient to allow full engagement into the mechanical lug. Flex-cable copper compression adapters shall be Shoo-pin PT-FX Series, as manufactured by Greaves Corporation, or equal.

5. Control Wiring Terminal Blocks

a. All starter units shall be provided with unit control terminal blocks (Type B wiring).

b. Terminal blocks shall be the pull-apart type with a minimum rating of 250 VAC and 10 A. All current carrying parts shall be tin plated. Terminals shall be accessible from inside the unit when the unit door is opened. Terminal blocks shall be DIN rail mounted with the stationary portion of the block secured to the unit. The stationary portion shall be used for factory connections, and shall remain attached to the unit when removed. The terminals used for field connections shall face forward so they can be wired without removing the unit or any of its components.
c. When Type C wiring is specified, all starter units shall be provided with unit control terminal blocks as described for Type B wiring along with power terminal blocks for NEMA size 1-3 units. An additional set of terminal blocks shall be provided in a terminal compartment located in each section. These terminal blocks shall be pre-wired to the unit terminals so that all field control connections can be made at the terminal compartments.

6. All internal wires shall be labeled at each termination. Terminals shall also be identified with labels showing the terminal block and terminal numbers.

7. Control wires connected to door mounted components shall be tied and bundled in accordance with good commercial practice. Bundles shall be made flexible at the hinged side of the enclosure. Adequate length and flex shall allow the door to swing full open without undue stress or abrasion. Bundles shall be held on each side of hinge by mechanical fastening devices.

8. Terminals on door mounted components shall be provided with finger-safe protective barriers; or alternatively, a single clear plastic protective barrier shall be provided covering all terminals.

K. Combination Full-Voltage Motor Controllers (Across-the-Line Starters)

1. Combination motor controllers shall be full-voltage non-reversing, unless otherwise specified herein or on the Drawings. Combination full-voltage motor controllers shall utilize motor circuit protectors and magnetic motor starters. Each combination unit shall have a short-circuit rating greater than or equal to the MCC main bus rating. The motor circuit protector shall provide adjustable magnetic protection, and shall be adjustable to 1700% of motor nameplate full load current in compliance with NEC requirements. All motor circuit protector combination starter units shall have a "tripped" position on the unit disconnect and a push-to-test button on the motor circuit protector. Motor circuit protectors shall be Eaton Type HMCP, or equal.

2. Where specified on the Drawings, motor circuit protectors shall be provided with auxiliary contacts (one normally open and one normally closed) that follow the position of the motor circuit protector main contacts for indication of "On" or "Off/Tripped".
3. Magnetic motor starters shall be NEMA ICS 2, alternating current Class A magnetic controllers for induction motors rated in horsepower. Magnetic motor starters shall be equipped with totally enclosed, double-break silver alloy contacts. Contact inspection and replacement shall be possible without disturbing line or load wiring. Starter wiring shall be straight-through with all terminals clearly marked. Each starter shall be provided with necessary number of normally open and/or normally closed auxiliary contacts to perform all functions shown on the control ladder diagrams in the Drawings.

4. Starter coils shall be of molded construction and permanently marked with voltage, frequency and manufacturer part number. Unless specified otherwise, starter coil voltage shall be 120 VAC.

5. Starters shall be provided with bimetallic-type overload relays or solid-state overload relays for motor protection. Overload relays for motor protection shall be as indicated on the Drawings and as specified herein. Unless specified otherwise, bimetallic-type overload relays shall be provided on starters for motors of less than 5 HP, and solid-state overload relays shall be provided on starters for motors of 5 HP and greater. For each combination motor controller, Contractor shall verify motor rating and coordinate starter and overload relay size with the horsepower and starting characteristics of the actual motor furnished.

6. Bi-metallic overload relays shall be ambient compensated with interchangeable heaters, calibrated for 1.0 and 1.15 service factor motors. Electrically isolated normally open and normally closed contacts shall be provided on the relay. The relay shall be capable of accepting additional auxiliary contacts. Visual trip indication shall be standard. A test trip feature shall be provided for ease of troubleshooting and shall be conveniently operable without removing components or the motor starter. The overload shall be capable of 20% (minimum) adjustability (plus or minus) and single-phase sensitivity. The overload relay shall be provided with an isolated alarm contact, and manual reset.

7. Solid-state overload relays shall be integral with the motor starter, and shall be listed under UL Standard 508. Solid-state overload relays separate from the motor starter are not acceptable. As a minimum, solid-state overload relays shall have the following features and capabilities:

a. Self-powered.

b. Class 10, 20, or 30 selectable tripping characteristics.
c. Manual or automatic reset. Automatic reset shall be provided if indicated on the Drawings. Reset shall be electronic 120 VAC.

d. Selectable "On/Off" phase loss protection. The relay shall trip in 10 seconds or less under phase loss condition.

e. Selectable "On/Off" phase imbalance protection. The relay shall trip in 10 seconds or less under phase imbalance condition.

f. Visible trip indication.

g. One normally open and one normally closed isolated auxiliary contact and capable of accepting additional auxiliary contacts.

h. Test button that operates the normally closed contact.

i. Test trip function that trips both the normally and normally closed contacts.

j. A current adjustment range of 3:1, or greater.

k. Embedded, selectable "On/Off" ground fault protection shall be an available option, and shall be provided where indicated on the Drawings. Relay shall trip when ground fault is detected at 50% of full load ampere setting.

l. An LED that provides self-diagnostic information.

m. An LED that aids in commissioning by indicating running current is too high compared to the FLA dial.

Solid-state overload relays shall be Eaton Type C440, or equal.

L. Solid-State Reduced Voltage Motor Controllers (Soft Starters)

1. The solid-state reduced voltage motor controller unit shall be a combination disconnect/soft starter, MCC-style unit. A molded case circuit breaker shall be provided for NEC required branch circuit protection. The branch circuit protection shall have an external operator. Wiring between the soft starter and the disconnect shall not be disturbed when removing or installing the soft starter controller unit from the MCC. Units shall be of modular construction so that units of the same size can be interchanged without modifications to the MCC structure.
2. All conducting parts on the line side of the unit disconnect shall be isolated to prevent accidental contact with those parts.

3. Soft starter units rated for standard duty (up to 156 A, FLA for 125 HP motor per NEC) shall be plug-in units which connect to the MCC vertical bus through a spring-reinforced stab-on connector. Units rated higher than 156 A shall be connected directly to the main horizontal bus with appropriately sized cable or riser bus.

4. The soft starter disconnect shall be a molded case circuit breaker per Part 2.04 herein.

5. For each soft starter unit, Contractor shall verify motor rating and coordinate soft starter and disconnect size with the horsepower and starting characteristics of the actual motor furnished.

6. All plug-in soft starter units shall have a grounded stab-on connector which engages the vertical ground bus prior to, and releases after, the power bus stab-on connectors engage/release.

7. All soft starter units shall be provided with unit control terminal blocks for use in terminating field wiring. Terminal blocks shall be pull-apart type, 250 V, and rated for 10 A. All current-carrying parts shall be tin-plated. Terminals shall be accessible from inside the unit when the unit door is opened. The terminals used for field connections shall be accessible so they can be wired without removing the unit or any of its components.

8. The enclosure shall include a door-mounted digital keypad for adjusting the soft starter parameters and viewing the motor, soft starter, and fault status without opening the enclosure door.

9. Each soft starter shall include a shorting contactor which closes after full voltage has been applied to the motor by the soft starter to reduce the current carrying duty on the SCRs. The shorting contactor shall be rated to carry the motor full load current during steady state operation.

10. Electrical Ratings

   a. The soft starter unit shall be designed to operate from an input voltage between -10% and +10% of nominal voltage rating.

   b. The soft starter unit shall operate from an input voltage frequency range of +/-5%.
c. The soft starter unit shall be capable of supplying 350% of rated full load current for 20 seconds at the maximum ambient temperature.

d. All soft starter unit power and control devices shall be rated for: severe duty capable of 3 evenly spaced starts per hour at 350% of full rated current for 24 seconds per start without tripping.

e. The soft starter unit shall be provided with silicon-controlled rectifiers (SCRs) having a minimum peak inverse voltage (PIV) rating of 1800 VAC. Lower rated SCRs with protection by metal oxide varistors (MOVs) are not acceptable.

11. Protection

a. A microprocessor-based thermal protection system shall be included that continuously calculates the temperature rise of the motor and soft starter and provides:

i. A motor overload fault that shall stop the motor if the windings have exceeded 125% of their rated temperature rise.

ii. An electronic circuit with a time-constant adjustable to the motor's thermal cooling time-constant that ensures memorization of the thermal state even if power is removed from the soft starter.

b. The soft starter shall provide line and motor phase loss, phase reversal, underload, stall, and jam protection.

c. The soft starter integral protective features shall be active even when the shorting contactor is used to bypass the SCRs during steady state operation.

d. All units and options shall be constructed with protection provisions to pass UL 845 short-circuit testing criteria at a minimum of 100,000 A short-circuit current.

e. Diagnostic faults and soft starter status shall be displayed on the door-mounted keypad after a fault condition.

f. The motor shall be automatically protected from solid state component failure by one of the following means:

i. Shunt trip coil to trip the disconnect in the event of a soft starter fault condition, including a shorted SCR.
ii. Isolation contactor that opens when the motor is stopped or when the controller detects a fault condition including a shorted SCR.

12. Adjustments and Configurations

a. All programming/configuration devices, display units, and field control wiring terminals shall be accessible on the front of the soft starter control module. All control circuit boards and electrical power devices shall be isolated to prevent exposure and accidental contact during routine adjustments.

b. Digital indication shall provide, as a minimum, the following conditions:

i. Soft starter status—ready, starting/stopping, run.
ii. Motor status—current, torque, thermal state, power factor, operating time, power in kW.
iii. Fault status—motor thermal overload, soft starter thermal fault, loss of line or motor phase, line frequency fault, low line voltage fault, locked rotor fault, motor underload, maximum start time exceeded, external fault, line phase reversal fault, and motor overcurrent fault.

c. As a minimum, a digital keypad shall be used to configure the following operating parameters:

i. Motor full load amps, adjustable from 40 to 100% of the soft starter’s rating.
ii. Current limitation on starting, adjustable from 200 to 700% of the motor current rating, not to exceed 350% of the soft start rating.
iii. Voltage ramp, adjustable from 1 to 60 seconds.
iv. Initial voltage, adjustable from 10 to 50% of nominal motor torque.
v. Maximum start time, adjustable from 1 to 250 seconds.
vi. Voltage boost duration, adjustable from 0.1 to 1 second.
vii. Selection of freewheel or soft stop.
viii. Linear (torque-controlled) deceleration ramp time, adjustable from 1 to 60 seconds.
ix. Selection of Class 10, 20, or 30 motor thermal overload protection.
d. As a minimum, a digital keypad shall be used configure the following controller parameters:

i. Assignment of soft starter inputs and outputs.
ii. Activation of phase reversal protection.
iii. Reset of motor thermal state.
iv. Return to factory parameter settings.
v. Activation of self-test mode.
vi. Indication of elapsed time in hours of starting, running and stopping.

e. As a minimum, output relays shall provide the following status indications:

i. One normally open SPST for indication of trip.
ii. One normally open SPST for indication that soft starter is running.

f. As a minimum, additional inputs and outputs shall be available to provide the following status indications:

i. Two assignable control inputs for the following functions: external fault input, disable serial link control, second set of operating and controller parameters, or general fault reset.

g. Relay and I/O functions listed above shall be isolated with respect to common.

h. Serial communication shall be provided with a communications card capable of ModBus RTU or ModBus TCP.

13. Control Options

a. The soft starter's control circuit shall be fed from a fused line supply and shall be completely independent of the power circuit and separate from relay control logic.

b. The peripheral soft starter control circuitry shall be operated from a control power transformer included within the enclosure.

c. Operator devices shall be door-mounted. Unless indicated otherwise on the Drawings, the following operator devices shall be provided:

i. Green "Start" and red "Stop" pushbuttons.
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14. Full-Voltage Bypass Starter

a. Where indicated on the Drawings, the soft starter unit shall include full-
voltage starting capability to start and control the motor instead of the
reduced voltage soft start method of starting the motor.

b. The full-voltage bypass starter shall include a magnetic motor starter as
specified herein, and shall be capable of carrying the motor inrush and
motor full load current.

c. A door-mounted "Normal/Bypass" selector switch shall be provided to
enable the user to manually select the motor starting method. "Normal"
mode shall provide reduced voltage starting using the soft starter. In
"Bypass" mode, the soft starter shall be left inactive and the motor shall
be started using the full-voltage (across-the-line) starter.

d. To protect the motor in "Bypass" mode, the magnetic motor starter shall
be equipped with a bi-metallic or solid-state overload relay, independent
of the soft starter.

e. The bypass starter components shall be fully integrated inside the soft
starter control unit and shall be factory tested by the MCC manufacturer.

M. Control Devices and Miscellaneous Components

1. Control Transformers

Except as otherwise indicated on the Drawings, each motor control unit shall be
provided with a control transformer. Control transformers shall comply with the
following requirements:

a. Each control transformer shall be rated 480/120 V, single phase, 2 wire,
60 Hz, and shall conform to the applicable requirements of NEMA ST 1.
The transformer shall have adequate volt-ampere capacity for the motor
starter coil and all connected control function loads indicated, plus an
additional 10 percent capacity. Transformer capacity shall be increased
as required for any additional non-control function loads, such as
condensation heaters and ventilation fans. The transformer shall have a minimum rating of 150 VA.

b. Each control transformer shall be feed from the load side of the motor controller disconnect. Control transformers shall be provided with two primary fuses rated to interrupt 100,000 A at 600 V. One transformer secondary lead shall be provided with a time-delay, slow-blow fuse rated to interrupt 10,000 A at 250 V, and the other secondary lead shall be grounded. All fuses shall be provided with blown fuse indicators.

Where Drawings indicate control circuit power is provided from a source other than a unit transformer (e.g. a lighting panel circuit breaker) and an interlock is required with the motor controller disconnect, the disconnect shall be equipped with a normally open contact to isolate the externally powered control circuit from the source when the controller disconnect is open.

2. Control Relays

Control relays shall be general purpose, electrically operated, magnetically held, plug-in blade or pin style with DIN rail mountable socket and LED indicator. Control relays shall be UL listed with 10 A rated contacts (thermal continuous current at 120 VAC), and shall be provided with 120 VAC coils, unless specified otherwise. Number of poles and pole arrangement shall be as indicated on the Drawings and as specified herein. Control relays shall be as manufactured by Allen-Bradley, IDEC, OMRON, Potter-Brumfield, or equal.

3. Time Delay Relays

Time delay relays shall be general purpose, multi-range, multi-function, plug-in blade or pin style with DIN rail mountable socket and LED indicators (timing and timed out). Time delay relays shall be provided with multiple programmable timing ranges (0.5 sec to 24 hours, minimum) and multiple operating modes. As a minimum, relay operating modes shall include: on-delay, off-delay, repeat cycle off start, repeat cycle on start, and signal on/off delay. Time delay relays shall be UL listed with 5 A rated contacts (thermal continuous current at 120 VAC) non-inductive load, and shall be provided with 120 VAC coils, unless specified otherwise. Number of poles, pole arrangement, and maximum timing adjustment shall be as indicated on the Drawings and as specified herein. Time delay relays shall be as manufactured by Allen-Bradley, IDEC, OMRON, Potter-Brumfield, or equal.
4. Elapsed Time Meters

Elapsed time meters shall be electromechanical, NEMA Type 4X rated, with rectangular or round case suitable for flush panel mounting. Each meter shall have 6-digit (minimum) registers with counter numbers at least 3 mm high, and shall be non-resetable. White counter numbers on black backgrounds shall provide hour indication with the last digit in contrasting colors to indicate tenths of an hour. Each meter shall operate on 120 VAC input power. Elapsed time meters shall be as manufactured by Eaton, Honeywell/Hobbs, or equal.

5. Pilot Devices

a. Pilot devices consisting of pushbuttons, selector switches, pilot lights, and incidental items shall be as manufactured by Allen-Bradley, Eaton/Cutler Hammer, or Schneider/Square D (no substitutes).

b. Pilot devices shall be suitable for mounting on MCCs, switchgear, control panels, and control stations. Pilot devices shall be 30.5 mm, NEMA Type 4/13 with cast metal bases, chrome-plated octagonal mounting nuts, and legend plates.

c. Pushbuttons and switch knobs shall be heavy duty plastic. Unless indicated otherwise on the Drawings, switch knobs shall be black and pushbuttons shall colors shall be as follows:

<table>
<thead>
<tr>
<th>Color</th>
<th>Function</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Emergency Stop, Stop, Off</td>
<td>Emergency Stop button, Master Stop button, Stop of one or more motors</td>
</tr>
<tr>
<td>Yellow (Amber)</td>
<td>Return, Emergency Return, Intervention (suppress abnormal conditions)</td>
<td>Return of machine to safe position, override other functions previously selected</td>
</tr>
<tr>
<td>Green</td>
<td>Start-On</td>
<td>General or machine start. Start of cycle or partial sequence.</td>
</tr>
<tr>
<td>Black</td>
<td>No specific function assigned</td>
<td>Permitted to be used for any function except for those listed above.</td>
</tr>
</tbody>
</table>

d. Contact blocks shall have AC contact ratings of NEMA A600, 10 A with silver contacts for corrosion resistance and clear side plates for contact inspection.
e. Pilot light devices shall be push-to-test type and shall be provided with LEDs and transformers suitable for operation on 120 VAC power. Pilot light lenses shall be shatter resistant plastic. Unless indicated otherwise on the Drawings, pilot light lens colors shall be as follows:

<table>
<thead>
<tr>
<th>Color</th>
<th>Function</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Fail or Alarm (abnormal condition requiring immediate attention)</td>
<td>Indication that a protective device has stopped the machine, e.g. overload</td>
</tr>
<tr>
<td>Yellow (Amber)</td>
<td>Warning (marginal condition, change or impending change of conditions)</td>
<td>Some value (e.g. pressure) is approaching its permissible limits. Overload permitted for a limited time. Ground fault indication.</td>
</tr>
<tr>
<td>White</td>
<td>Normal Condition, Confirmation</td>
<td>Normal pressure. Control power on.</td>
</tr>
</tbody>
</table>

f. Where MCC control pushbuttons, switches and lights are shown on the Drawings, each motor control unit shall be provided with a hinged/removable control station plate, suitable for accommodating a minimum of three (3) 30.5 mm pilot devices. Additional pilot devices, where shown, shall be located on the control unit door. Manufacturer shall confirm the location of the pilot devices with the District prior to commencing equipment fabrication.

6. Power Meter

a. The power meter shall be UL listed. The meter shall be designed for multifunction electrical measurement on three-phase power systems. The meter shall perform as specified in harsh electrical applications in high and low voltage power systems.

i. The meter shall support 3 element wye, 2.5 element wye, 2 element delta, and 4 wire delta systems.

ii. The meter shall accept universal voltage input.

iii. The meter shall be user programmable for voltage range to any potential transformer ratio.
b. The meter shall use a dual input method for current inputs. One method shall allow the current transformer (CT) to pass directly through the meter without any physical termination on the meter, ensuring the meter cannot be a point of failure on the CT circuit. The second method shall provide additional termination pass-through bars, allowing the CT leads to be terminated on the meter. The meter shall support both termination methods.

i. Fault current withstand shall be 100 A for 10 seconds, 300 A for 3 seconds, and 500 A for 1 second.

ii. The meter shall be programmable for current to any CT ratio. DIP switches or other fixed ratios shall not be acceptable.

iii. All inputs and outputs shall be galvanically isolated to 2500 VAC.

iv. The meter shall accept current inputs of Class 10: 0 to 10 A (5 A nominal), and Class 2: 0 to 2 A (1A nominal) secondary.

c. The meter shall have an accuracy of +/- 0.1% or better for voltage and current, and 0.2% for power and energy functions. The meter shall have a frequency measurement accuracy of not less than 0.001 Hz.

i. The meter shall provide true RMS measurements of voltage (phase-to-neutral, phase-to-phase) and current (per phase and neutral).

ii. The meter shall calculate RMS readings, sampling at over 400 samples per cycle on all channels measured readings continuously with no cycle blind spots.

iii. The meter shall provide voltage and current distortion measurements (% of total harmonic distortion). Harmonic magnitude recording to the 40th order shall be available for voltage and current harmonics.

d. The meter shall be capable of simultaneously recording voltage and current waveforms.

i. The meter shall be capable of recording 512 samples per cycle for a voltage sag or swell or a current fault event.

ii. The meter shall provide pre-event and post-event recording capability.

iii. The meter shall allow up to 170 events to be recorded.

e. The meter shall be suitable for flush door mounting. The meter shall be provided with a three-line, LED display. The meter shall display a percent of load bar on the front panel. The percent of load bar shall have not less than 10 segments.
f. The meter shall be a traceable revenue meter, which shall contain a utility grade test pulse allowing power providers to verify and confirm that the meter is performing to its rated accuracy.

g. Power meter shall include virtual measurement upgrade packs, which shall allow field upgrades without removing the installed meter.

i. As a minimum, the meter shall be provided with an upgrade pack that provides multifunction metering consisting of: volts, amps, kW, kVAR, PF, kVA, frequency, kWh, kVAh, kVARh, and I/O expansion.

ii. The meter shall be provided with 2 MB of memory for data logging.

h. The meter shall include 2 independent communications ports on the back and face plate, with advanced features. The back plate communication port shall provide RS485 communication in Modbus protocol. The face plate communication port shall be an optical IrDA port (through faceplate), which shall allow the unit to be set up and programmed using a handheld device or remote laptop without need for a communication cable.

i. The meter shall provide a user configured fixed window or rolling window demand for a variable user utility demand profile. The meter shall provide an update rate of every 6 cycles for watts, VAR and VA. All other parameters shall be updated every 60 cycles.

j. The meter shall support a power supply of 90 to 265 VAC and 100 to 370 VDC, and shall have a burden of less than 11VA.

k. The meter shall have data logging capability with 2 MB memory. The meter shall have a real-time clock that allows for time stamping of all the data in the meter when log events are created. The meter shall be capable of maintaining six logs:

i. The meter shall have three historical logs for trending profiles. Each log shall be capable of being programmed with up to 64 parameters. The user shall have the ability to allocate memory between the three historical logs in order to increase or decrease the memory allotted to each of the logs.

ii. The meter shall have a log for limits alarms. The limits log shall provide magnitude and duration of an event, time-stamp, and log value. The log must be capable of recording to 2048 events.
The meter shall have a log for system events. The system events log shall record the following occurrences with a time-stamp: demand resets, password requests, system startup, energy resets, log resets, log reads, programmable settings changes.

The meter shall have a log for I/O changes. The I/O change log shall provide a time-stamped record of any relay outputs and any input status changes. The log must be capable of recording up to 2048 events.

The meter shall have I/O expandability through two option card slots on the back. The meter shall auto-detect the presence of any I/O option cards. The meter shall be furnished with an option card that provides four pulse outputs and 4 status inputs.

The pulse output/digital input option card shall provide the following features:

1. 4 KYZ pulse/4 status inputs.
2. Programmable to any energy parameter and pulse value.
3. Programmable to end of interval pulse.
4. 120mA continuous load current.
5. DNP input.

The power meter shall be rated NEMA Type 12, and shall be capable of operating in ambient temperatures of -20 to +70°C. The meter shall have a standard 4-year warranty. The power meter shall be Electro Industries/Gauge Tech Model Shark 200-60-10-V1-D2-PO1S-X (no substitutes).

Lighting panelboards and transformers shall be as specified in Part 2.03 herein and as indicated on the Drawings.

Heating and ventilation shall be as designed by the manufacturer, and shall comply with the requirements specified herein and indicated on the Drawings. MCCs shall be equipped with heating and ventilation equipment and components as specified herein, and in accordance with the manufacturer’s design requirements.
1. **MCCs Located Indoors**

   Unless indicated otherwise on the Drawings, MCCs located indoors shall be provided with NEMA 1A, gasketed enclosures. As a minimum, MCC NEMA 1A enclosures shall comply with the following heating and ventilation requirements:

   a. All MCC sections, except sections with bottom feed main lugs, bottom feed mains and branches over 600 A, and lighting panel transformers, shall be provided with space heaters to prevent condensation. Space heaters shall operate on 120 V, 60 Hz power. Line voltage thermostats shall be provided for controlling the space heaters. The thermostats shall monitor the temperature inside the NEMA 1A enclosures with temperature adjustment accessible from the outside face of the enclosures.

   b. Unless specified otherwise, MCC sections equipped with variable frequency drives or soft starters, shall be provided with forced air ventilation cooling as required to maintain the ambient temperature for the housed equipment to no greater than its maximum ambient temperature rating for continuous operation at full rated capacity.

   c. Forced air ventilation shall be provided with supply fans mounted at the bottom of the enclosure doors. The bottom door fans shall force fresh air into the enclosure through ventilation louvers located at the bottom of the doors to create a positive internal air pressure; and thereby, forcing out dirt and contaminants, and moving warm air out through ventilation louvers located at the top of the doors. A factory installed thermostat shall control the fans based on the MCCs internal temperature; or alternatively, fan operation shall be controlled by “run” operation of the variable frequency drive or soft starter. Door interlock switches shall be provided to turn the fans off when the door is opened. Unless specified otherwise, each ventilation louver (top and bottom) shall be covered by an air filter. Air filters shall be washable aluminum mesh type, gasketed on all sides, and removable (without the use of tools) for cleaning.

   d. Control power transformers with primary and secondary fuse protection shall be provided as required for proper operation of the enclosure heating and ventilating equipment, unless Drawings show otherwise. Supply voltage shall be 120 V, 60 Hz. The control power transformers shall be prewired at the factory to all fans, space heaters, and temperature controls. Separate line voltage thermostats shall be provided for heating and cooling.
2. **MCCs Located Outdoors**

   Unless indicated otherwise on the Drawings, MCCs located outdoors shall be provided with NEMA 3R, non-walk-in enclosures. Heating and ventilation requirements for MCC NEMA 3R, non-walk-in enclosures shall be in addition to the requirements specified above for NEMA 1A enclosures. As a minimum, MCC NEMA 3R enclosures shall be comply with the following heating and ventilation requirements:

   a. All heating and ventilation requirements for NEMA 1A, gasketed enclosures specified above shall apply for the interior MCC sections.

   b. Where NEMA 1A enclosures are provided with fans for ventilation, NEMA 3R wrapper doors shall be provided with supply fans mounted at the bottom of the enclosure doors. The bottom door fans shall force fresh air into the vestibule space between the wrapper doors and NEMA 1A enclosure to create a positive internal air pressure; and thereby, forcing out dirt and contaminants, supplying fresh air to interior MCC sections, and moving warm air out through ventilation louvers located at the top of the doors. NEMA 3R wrapper line voltage thermostats (separate from the MCC cooling thermostats) shall control the outer door mounted fans based on the temperature in the vestibule space; or alternatively, fan operation shall be controlled by “run” operation of the variable frequency drive or soft starter. Door interlock switches shall be provided to turn the fans off when the outer doors are opened.

   c. Heating shall consist of the space heaters and thermostats specified above for the NEMA 1A enclosure. No additional heating is required for the NEMA 3R wrapper.

   d. Openings for supply air and exhaust air in NEMA 3R wrapper doors shall be provided with integral louvers or weatherproof hoods as specified herein.

   e. Heating and ventilation shall be as designed by the manufacturer, and shall comply with the requirements specified herein and indicated on the Drawings. If the NEMA 3R wrapper is fabricated by a third party manufacturer, the MCC manufacturer shall review the ventilation design and certify in writing that the proposed ventilation system is properly designed and the MCC manufacturer’s warranty for the MCC equipment is in full effect.
f. Control power transformers with primary and secondary fuse protection shall be provided as required for proper operation of the NEMA 3R wrapper fans and thermostats, unless Drawings show otherwise. Supply voltage shall be 120 V, 60 Hz. The control power transformers shall be prewired at the factory to all fans and temperature controls.

2.02 SWITCHBOARDS

A. General

1. Service and distribution switchboards shall be 600 V class suitable for operation on a three-phase, 480 V, 60 Hz system. Switchboards shall be configured for 3-wire or 4-wire systems, as indicated on the Drawings. Switchboards shall be manufactured by Eaton/Cutler-Hammer, Schneider Electric/Square D, or General Electric (no substitutes).

2. Switchboards shall be manufactured in compliance with UL 891 and shall be UL labeled.

3. Switchboard amperage ratings, including all devices, shall be based on a maximum ambient temperature of 40°C per UL Standard 891. With no de-rating required, temperature rise of switchboards and devices shall not exceed 65°C in a 40°C ambient environment. Where specified, switchboards and devices shall be suitable for operation in a 50°C ambient environment with the appropriate de-rating factors incorporated into the equipment design as certified by the manufacturer.

B. Structure

1. Switchboards shall be front accessible with fixed individually mounted or drawout mounted main protective devices and fixed individually mounted or panel mounted bolt-on protective devices.

2. Switchboards shall be fully self-supporting structures with 90 inch (nominal) tall vertical sections (excluding lifting eyes and pull boxes) bolted together to form the required arrangement.

3. Switchboard frame shall be die formed, 12 gauge (minimum) steel with reinforced corner gussets. Frame shall be rigidly bolted to support cover plates (code gauge steel), bus bars and installed devices during shipment and installation. All covers shall be attached with hex head bolts.
4. Switchboards shall be capable of being bolted directly to a concrete floor or slab without the use of floor sills. All switchboard sections shall have open bottoms and removable top plate(s) to install conduit as shown on the Drawings.

5. Front covers shall be screw removable with a single tool and doors shall be hinged and provided with removable hinge pins. All edges of front covers shall be formed.

6. Unless indicated otherwise herein or on the Drawings, the incoming pull section shall be bused. Incoming cable entry into the pull section shall be as shown on the Drawings.

7. Distribution sections shall be bussed and shall be matched and aligned with the basic switchboard. Bus transition and incoming cable pull sections shall be matched and aligned with the basic switchboard.

8. Barriers shall be provided between adjacent switchboard sections. A vertical insulating barrier shall be provided between the incoming cable pull section and the main bus to protect against inadvertent contact with main or vertical bus bars. Through-busing shall be taped to provide insulation and isolation.

9. Service switchboard shall be suitable for use as service entrance equipment. Service switchboard incoming pull section, and utility metering compartment and section shall be fabricated in accordance with utility company's requirements and UL service entrance requirements, including UL service entrance label, incoming line isolation barriers, and removable neutral bond to switchboard ground for solidly grounded wye systems. If a separate vertical section is required for utility metering, it shall be matched and aligned with the basic switchboard.

10. Where indicated on the Drawings, switchboard shall be provided with top mounted pull box. Adequate ventilation shall be provided to maintain temperature in pull box within the same limits as the switchboard. Bottom of pull box shall be constructed of insulating, fire-resistive material with separate holes for cable drops into switchboard.

11. The switchboard assembly shall be provided with adequate lifting means (e.g. lifting eyes or lifting bars).

C. Buses

1. All bus bars shall be hard-drawn tin-plated copper of 98 percent conductivity. Plating shall be applied continuously to bus work.
2. The phase through-busing shall have a minimum ampacity as indicated on the Drawings. The main incoming bus bars shall be rated for the same ampacity as the through-busing. For four-wire systems, the neutral bus shall be of equivalent ampacity as the phase bus bars. Tapered bus is not permitted. Busing shall be of sufficient cross-sectional area to meet UL 891 temperature rise requirements. Plating shall be applied continuously to bus work.

3. Ground bus shall be sized per NEC and UL 891 Tables 28.1 and 28.2. Ground bus shall be firmly secured to each vertical section structure and shall extend the entire length of the switchboard.

4. Where indicated on the Drawings, full provisions for the addition of future sections shall be provided. Bussing shall include, but not be limited to, all necessary hardware to accommodate splicing for future additions.

5. Where indicated on the Drawings, equip compartments designated for future protective devices with mounting brackets, supports, bus connections, and appurtenances at the full rating of the future device. Compartments for future devices shall be provided with all necessary straps, hardware, and filler plates to completely cover the openings.

6. Isolation barriers shall be configured to permit access to busing for verification of bus bolt torque.

7. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with conical spring-type washers.

8. The bus system shall be rated for an available short-circuit capacity of not less than 65,000 RMS amperes. If the results of the Contractor’s Electrical Short-circuit and Protective Device Evaluation and Coordination Study, as accepted by the District, indicate that a higher short-circuit duty rating of the switchboard is required, Contractor shall furnish the switchboard with that higher rating.

D. Instrument Transformers

1. All instrument transformers shall be UL listed.

2. Current transformers shall be provided with ratios, accuracy class and burden to support connected meters, relays and instruments, as required by ANSI/IEEE C57.13.
3. Potential transformers shall be provided with secondary voltage rating of 120 V (unless specified otherwise) and shall be provided with burden and accuracy to support connected meters, relays and instruments, as required by ANSI/IEEE C57.13.

4. Control power transformers shall be dry type and mounted in separate compartments for units larger than 3 KVA.

5. Where current transformers for neutral and ground fault current sensing are required, connect secondaries to ground overcurrent relays to provide selective tripping of main and tie circuit breaker (where specified). Coordinate with feeder circuit breaker ground fault protection.

E. Control Power

1. Control Circuits: 120 volts, supplied through secondary disconnecting devices from control power transformer.

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

F. Wiring and Terminations

1. Copper compression type lugs shall be provided for all line and load terminations, and shall be suitable for copper cable rated for 75°C of the size as indicated on the Drawings.

2. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors, including branch circuit ground conductors, shall be provided as indicated on the Drawings.

3. Where fine stranded conductors, Class C and higher (such as DLO cable) are utilized for internal wiring, all terminations in mechanical lugs shall be provided with copper flex-cable compression adapters to properly confine the fine strands and prevent overheating of the connection and wire pullout from lugs. The flex-cable compression adapters shall fit mechanical set-screw mechanical lug type connectors and shall be sized for the full current carrying capacity of the cable. The adapters shall be provided a flared barrel-opening to allow easy cable insertion. The adapter shall be constructed of wrought copper with pin of Class B stranded copper conductor, rated for 600V and 105°C cable, and shall be UL listed. Pin length shall be sufficient to allow full engagement into the mechanical lug. Flex-cable copper compression adapters shall be Shoo-pin PT-FX Series, as manufactured by Greaves Corporation, or equal.
4. Control wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. Control wiring shall be factory installed with bundling, lacing and protection included. Factory control wiring shall include conductors for interconnections between shipping units.

5. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer’s wiring diagrams.

6. All control wire shall be bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle-type terminals provided are integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short-circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

7. Control wires connected to door mounted components shall be tied and bundled in accordance with good commercial practice. Bundles shall be made flexible at the hinged side of the enclosure. Adequate length and flex shall allow the door to swing full open without undue stress or abrasion. Bundles shall be held on each side of hinge by mechanical fastening devices.

G. Enclosures

1. Switchboards Located Indoors

Unless indicated otherwise on the Drawings, switchboards located indoors shall be provided with free standing NEMA Type 1 enclosures. As a minimum, switchboard NEMA 1 enclosures shall comply with the following requirements:

a. Enclosures shall be provided in accordance with UL 891 requirements. Each enclosure shall be adequately ventilated to limit the temperature rise of the switchboard and all devices to 65°C in a 40°C ambient environment. Top and bottom conduit areas shall be clearly indicated on the shop drawings.

b. Ventilation openings shall be covered by interior mounted air filters. Air filters shall be washable aluminum mesh type and shall be removable (without the use of tools) for cleaning.
2. Switchboards Located Outdoors

Unless indicated otherwise on the Drawings, switchboards located outdoors shall be provided with NEMA Type 3R, non-walk-in (rainproof) enclosures. Switchboard NEMA Type 3R, non-walk-in enclosures shall be based on free standing NEMA Type 1 enclosures with a NEMA 3R wrapper. The additional housing supplied by the NEMA 3R wrapper shall provide protection from rain, sleet, and ice. As a minimum, switchboard NEMA Type 3R, non-walk-in enclosures shall comply with the following requirements:

a. The enclosing NEMA 3R wrapper shall be constructed of 12 gauge galvanneal steel with a flat or sloped roof line. Sloped roof lines shall be sloped from front to rear at a minimum of 1/2 inch per foot. Doors shall be louvered and hooded at top and bottom, and gasketing shall be provided around four door closing flanges.

b. Each NEMA 3R wrapper split or section shall have a minimum of 30 inches working clearance from hinge flange to door closure flange. The width of open unobstructed area when door is open shall be 30 inches minimum.

c. NEMA 3R wrapper splits shall be coordinated with the switchboard section splits. Cabinet spacers shall be provided at switchboard section splits to permit full opening (90 degrees, minimum) of all switchboard doors without interfering with the NEMA 3R wrapper doors. Switchboard shall be provided with all cabinet spacers, through-bus splice kits, neutral bus splice kits, and ground bus splice kits required to interconnect switchboard sections and provide the necessary separation for switchboard doors to fully open.

d. The distance between the front of the interior switchboard section and the outer doors shall be 11 inches, minimum.

e. Interior lighting shall be provided in the NEMA 3R wrapper vestibule using LED lighting fixtures, single-tube, with length as necessary for width of NEMA 3R wrapper split. A light switch shall be provided on side extension for each switchboard shipping split, and shall be furnished with a stainless steel cover plate.

f. Convenience receptacles shall be provided for each switchboard shipping split, and shall be duplex GFCI type, with stainless steel cover.
g. All switchboard sections, except pull sections, shall be provided with space heaters. Space heaters shall be provided with adequate wattage to prevent condensation. Space heaters shall be installed within the NEMA 1 switchboard sections and shall operate on 120 V, 60 Hz power. Line voltage thermostats shall be provided for controlling the space heaters. The thermostats shall monitor the temperature inside the NEMA 1 enclosures with temperature adjustment accessible from the outside face of the enclosures.

h. NEMA 3R wrapper doors shall be provided with ventilation openings as required for proper cooling of the switchboard and devices. As a minimum, each ventilation opening shall be provided with louvers integrally molded into the door and covered by interior mounted air filters with gasketing. Air filters shall be washable aluminum mesh type and shall be removable (without the use of tools) for cleaning. Alternatively, ventilation openings in doors may be clear openings covered by exterior weatherproof hoods. Openings shall be provided with washable air filters as specified above. In addition, openings at the bottom of the hoods shall be provided with removable insect screens.

i. Heating and ventilation shall be as designed by the manufacturer, and shall comply with the requirements specified herein and indicated on the Drawings. If the NEMA 3R wrapper is fabricated by a third party manufacturer, the switchboard manufacturer shall review the ventilation design and certify in writing that the proposed ventilation system is properly designed and the switchboard manufacturer’s warranty for the switchboard equipment is in full effect.

j. NEMA 3R wrapper front door handles shall have provisions for padlocking and shall be equipped with wind stops.

k. Control power transformers shall be provided within the switchboard to supply power to the space heaters, interior lighting, and receptacles. Control power transformers shall be equipped with primary and secondary fuse protection. Supply voltage shall be 120 V, 60 Hz. The control power transformers shall be prewired at the factory to all space heaters, temperature controls, interior lighting, and receptacles.

H. Finish

1. All steel parts shall be provided with UL listed acrylic/alkyd baked enamel paint finish or TGIC Powder Coat, except plated parts used for ground connections. All painted parts shall undergo a multi-stage treatment process, followed by the finishing paint coat.
2. Pre-treatment shall include:
   a. Hot alkaline cleaner to remove grease and oil.
   b. Iron phosphate treatment to improve adhesion and corrosion resistance.

3. The paint shall be applied using an electro-deposition process to ensure a uniform paint coat with high adhesion.

4. The standard paint finish shall be tested to UL 50 per ASTM B117 (5% ASTM Salt Spray) with no greater than 0.125 inch loss of paint from a scribed line.

5. Paint color for switchboard NEMA 1 enclosures shall be #49 medium light gray per ANSI Standard Z55.1 (60-70 gloss) on all surfaces, unless specified otherwise.

6. Paint color for switchboard NEMA 3R enclosures (NEMA 3R wrappers) shall be white (60-70 gloss) on all surfaces, unless specified otherwise.

I. Protective Devices

1. Switchboard protective devices shall be furnished as indicated on the Drawings and specified herein, including interconnections, instrumentation and control wiring.

2. Main protective devices shall be fixed individually mounted or drawout mounted. Branch protective devices shall be fixed individually mounted or group mounted with bolted connections.

3. Protective devices shall be provided with frame sizes as indicated on the Drawings. Protective devices with frame sizes less than or equal to 2000 A shall be molded case circuit breakers as specified in Part 2.04D, herein. Unless specified otherwise, protective devices with frame sizes greater than 2000 A shall be insulated case power circuit breakers as specified in Part 2.04E herein. The short-circuit current rating of the protective devices shall be greater than or equal to the switchboard bus rating.
J. Utility Metering and Main Disconnect

1. Main Service Switchboard

Where indicated on the Drawings, main service switchboard shall consist of pull section, utility service (metering) section, and main protective device. Main service switchboard shall be provided in accordance with the requirements specified herein and as indicated on the Drawings.

Equipment shall include a separate, barriered-off, utility metering compartment complete with hinged sealable door as approved by the utility company. Bus work shall include provisions for mounting utility company current transformers, potential transformers, potential taps, test devices, and metering as required by the utility company. Switchboard neutral to ground bonding connection shall be in accordance with utility company requirements. Provide Service Entrance Label and provide necessary applicable service entrance features per NEC, local code requirements, and utility company requirements.

All electrical service equipment shall be in strict accordance with utility company requirements and requirements specified herein. In cases of conflict between the requirements specified herein and the requirements of the utility company, the more stringent requirement shall prevail. Prior to commencing fabrication of electrical service equipment, Contractor shall submit shop drawings of proposed equipment to utility company and District for review and approval.

2. Main Protective Device

Main protective device shall be a molded case circuit breaker or insulated case power circuit breaker as specified in Part 2.04 herein. Circuit breaker shall be provided with a microprocessor-based RMS sensing trip unit, and shall be equipped with ground fault protection and arc-flash reduction maintenance system. Circuit breaker frame size and shall be as indicated on the Drawings. Circuit breaker short-circuit current rating shall be greater than or equal to the switchboard bus rating.

Main circuit breaker shall be equipped with ground fault protection and arc-flash reduction maintenance mode and be capable of remote operation via a switch located in the MCC.

2.03 LIGHTING PANELBOARDS AND TRANSFORMERS

A. Manufacturers

Lighting panelboards and transformers shall be manufactured by Eaton/Cutler-Hammer, Schneider/Square D, or General Electric (no substitutes).
B. **General**

1. Lighting panelboards mounted in MCCs shall be constructed integrally with the MCC and shall match the finish of the MCC. Lighting panelboards, branch circuit breakers, and transformers mounted in MCCs shall meet the applicable requirements specified herein.

2. Standalone lighting panelboards and transformers shall be provided in accordance with the requirements specified herein. Standalone lighting panelboards shall be suitable surface mounting or flush mounting as indicated on the Drawings.

C. **Ratings**

1. 240 V lighting panelboards shall be rated to withstand a minimum fault current of 22,000 amperes symmetrical, unless a higher fault current is indicated on the Drawings or determined by Contractor’s Electrical Short-circuit and Protective Device Evaluation and Coordination Study.

2. Equipment shall meet both UL891 and UL67 thermal standards.

D. **Interior**

1. Panelboard interiors mounted in MCCs shall be flush mounted with the front of the enclosure to allow easy access to line and/or load conductors entering/exiting top or bottom. Recessing the panel interior more than 3 inches from the front of the enclosure will not be acceptable.

2. Panelboard interior shall be compartmentalized with steel walls on all four sides. Panelboard shall be sized to provide a minimum of 4 inches of gutter space on all sides.

3. Panelboard main breakers shall be integral to the panel interior. Main breakers separate from the interior will not be acceptable.

4. Provide one continuous bus bar per phase. Each bus bar shall have sequentially phased branch circuit connectors suitable for bolt-on branch circuit breakers. The bussing shall be fully rated. Panelboard bus current ratings shall be determined by heat-rise tests conducted in accordance with UL 67. Bussing shall be plated copper. Aluminum bussing will not be acceptable. Bus bar plating shall run the entire length of the bus bar.

5. Current carrying parts shall be insulated from ground and phase-to-phase by high dielectric strength thermoplastic.
6. Panelboard shall be provided with a solidly bonded, plated copper, equipment ground bar(s). Ground bar(s) shall be adequate for terminating ground conductors for the maximum number of panel circuits.

7. Panelboard shall be provided with full size neutral bars with suitable lugs for the maximum number of panel circuits. Neutral bars with shall be plated copper and shall be located in the main compartment so incoming neutral cable may be of the same length.

8. Panelboard interior shall be provided with nameplates containing system information and catalog number or factory order number. Interior wiring diagram, neutral wiring diagram, UL-listed label, and short-circuit current rating shall be displayed on the interior.

E. Fronts

1. Trim front shall one-piece, bolt-on type with door, and shall meet strength and rigidity requirements of applicable UL 50 standards. Door shall have rounded corners and edges free of burrs.

2. Interior trim shall be of deadfront construction to shield user from energized parts. Deadfront trim shall have filler plates covering unused circuit breaker mounting spaces.

3. Fronts for NEMA Type 1 enclosures shall have flush cylindrical tumbler lock with catch and spring-loaded stainless steel door pull. All lock assemblies shall be keyed alike. Two keys shall be provided with each lock. Front shall not be removable with the door locked.

4. A clear plastic directory cardholder with typed circuit directory shall be mounted on the inside of the door. Adhesive circuit directories are not acceptable.

F. Enclosures

1. Enclosures for lighting panelboards mounted in MCCs shall be constructed integrally with the MCC enclosure.
2. Enclosures for standalone lighting panelboards shall be provided in accordance with the following:
   a. Enclosures shall be constructed of galvannealed steel with a ANSI #49 gray enamel electrodeposited over cleaned phosphatized steel. Enclosures shall be constructed in accordance with UL 50 and 50E requirements.
   b. Unless indicated otherwise on the Drawings, indoor enclosures shall be NEMA Type 1 gasketed, and outdoor enclosures shall be NEMA Type 3R gasketed.
   c. Outdoor NEMA Type 3R enclosures shall be provided with a padlockable hasp to secure the door.

G. Main Circuit Breaker

1. Main circuit breakers for lighting panelboards shall be molded case thermal-magnetic circuit breakers. Circuit breakers shall be provided with inverse time-current elements for low-level overloads and instantaneous magnetic trip elements for short-circuits. Circuit breakers shall be UL listed with amperage ratings and number of poles as indicated on the Drawings.

2. Main circuit breaker interrupting rating shall be selected to match the lighting panelboard short-circuit current rating (minimum 22,000 RMS symmetrical amperes).

3. Main circuit breaker shall have an over-center, trip-free, toggle mechanism which shall provide quick-make, quick-break contact action. Circuit breaker shall have a permanent trip unit with thermal and magnetic trip elements in each pole. Each thermal element shall be true RMS sensing and shall be factory calibrated to operate in a 40°C ambient environment. Thermal elements shall be ambient compensating above 40°C.

4. Two-pole and three-pole circuit breakers shall have common tripping of all poles. Circuit breaker frame sizes above 100 amperes shall have a single magnetic trip adjustment located on the front of the circuit breaker that shall allow the user to simultaneously select the desired trip level of all poles. Circuit breakers shall have a push-to-trip button for maintenance and testing purposes.

5. Circuit breaker handle and faceplate shall indicate rated ampacity. Circuit breaker shall be provided with handle accessories for locking handle in the off position.
6. Circuit breaker lugs shall be UL-listed to accept solid or stranded copper conductors only. Lug sizes shall be based on conductor ampacities corresponding to those shown in NEC Table 310-16 for 75°C rated wire.

7. Circuit breakers shall be bolted-on type. Snap-in designs are not acceptable.

8. Main circuit breakers shall be UL-listed for use with the following factory installed accessories: shunt trip, under voltage trip, ground fault trip, auxiliary switch, alarm switch, and mechanical lug kits. Main circuit breaker accessories shall be provided as indicated on the Drawings.

H. Branch Circuit Breakers

1. Branch circuit breakers for lighting panelboards shall be molded case thermal-magnetic circuit breakers. Circuit breakers shall be provided with inverse time-current elements for low-level overloads and instantaneous magnetic trip elements for short-circuits.

2. Branch circuit breakers shall be HACR type, unless specified otherwise. Breakers shall be UL-listed with amperage ratings and number of poles as indicated on the Drawings. Unless specified otherwise, minimum amperage rating for branch circuit breakers shall be 20 A, and amperage rating for spare circuit breakers shall be 20 A.

3. Interrupting ratings of branch circuit breakers shall match rating of main circuit breaker.

4. Molded case branch circuit breakers shall be bolt-on type. Snap-in designs are not acceptable.

5. Circuit breakers shall have an over-center, trip-free, toggle mechanism which shall provide quick-make, quick-break contact action. Circuit breakers shall have thermal and magnetic trip elements in each pole. Two-pole and three-pole circuit breakers shall have common tripping of all poles. Thermal trip elements shall be factory preset and sealed. Circuit breakers shall be true RMS sensing and thermally responsive to protect circuit conductors in a 40°C ambient temperature.

6. Circuit breakers shall be provided with two forms of visible trip indication. The circuit breaker handle shall reside in a position between on and off. In addition, there shall be a red indicator appearing in the clear window of the circuit breaker housing.
7. The exposed faceplates of branch circuit breakers shall be flush with one another.

8. Ground Fault Current Interrupting (GFCI) circuit breakers shall be provided where indicated on the Drawings. GFCI circuit breakers shall be UL Class A with 30 mA sensitivity.

9. Circuit breaker lugs shall be UL-listed to accept solid or stranded copper conductors only. Lug sizes shall be based on conductor ampacities corresponding to those shown in NEC Table 310-16 for 75°C rated wire.

I. Lighting Panel Transformers

1. Transformers for lighting panels shall be energy efficient (NEMA TP-1 compliant or Energy Star labeled), dry type, and UL listed with a minimum KVA rating as indicated on the Drawings. Unless specified otherwise, transformers shall be single phase, 480 V primary and 120/240 V secondary.

2. Transformer shall be "K" rated for high harmonic loads when non-linear loads are present.

3. Transformers shall be provided with a minimum of 4 full capacity primary winding taps. Unless specified otherwise, 2 winding taps shall be provided at 2.5 percent above nominal, and 2 winding taps shall be provided at 2.5 percent below nominal.

4. Transformer insulation system shall be rated at 220°C and designed for full load operation at a maximum of 115°C temperature rise above 40°C ambient. Transformers shall be capable of carrying a 15 percent continuous overload without exceeding a 150°C temperature rise above 40°C ambient.

5. Transformer coils shall be copper continuous wound construction and shall be impregnated with non-hygroscopic thermosetting varnish.

6. Each transformer winding shall be provided with an electrostatic shield arranged to minimize inter-winding capacitance.

7. Fan cooled transformers will not be acceptable.

8. Sound level shall be warranted by the manufacturer not exceed 45 decibels measured at 5 feet from the transformer.

9. The secondary side neutral conductor of the transformer shall be factory grounded.
10. The core of the transformer shall be grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.

11. Transformers shall be factory installed in a freestanding enclosure (except for MCC applications), NEMA Type 1 for indoor locations and NEMA Type 3R for outdoor locations. Transformer enclosures shall be ventilated and fabricated of heavy gauge, sheet steel construction. The entire enclosure shall be finished utilizing a continuous process consisting of degreasing, cleaning and phosphatizing, followed by electrostatic deposition of polymer polyester coating and baking cycle to provide uniform coating of all edges and surfaces. The coating shall be UL recognized for outdoor use. The coating color shall be ANSI #49, gray.

2.04 PROTECTIVE DEVICES

A. General Requirements for Molded Case Circuit Breakers

1. Molded case circuit breakers shall be UL listed and conform to UL 489 and NEMA AB1. Molded case circuit breakers shall be as manufactured by Eaton/Cutler-Hammer, Schneider/Square D, General Electric, or approved equal.

2. Unless specified otherwise, mold case circuit breakers shall be thermal-magnetic type with inverse time-current thermal element for low-level overloads, and instantaneous magnetic trip element for short-circuits.

3. Circuit breakers shall be provided with ambient temperature compensating thermal trips for a minimum range of 10 to 50 °C.

4. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

5. Breakers specified for operation on a 480 V, 60 Hz system shall be rated for 600 V and shall have a minimum symmetrical interrupting capacity of 65,000 A. Breakers shall be provided with a higher interrupting capacity, if indicated on the Drawings or required by the Contractor’s Electrical Short-circuit and Protective Device Evaluation and Coordination Study.
6. Circuit breaker amperage rating shall be as required to protect the specified branch circuit and equipment. Contractor shall coordinate circuit breaker amperage rating with actual equipment to be furnished. Minimum circuit breaker amperage rating shall be as indicated on the Drawings.

7. Contractor shall coordinate the applicable circuit breaker sensor, trip unit, and rating plug with the required amperage rating.

8. Where indicated on the Drawings, circuit breakers shall be UL listed for application in their intended enclosures at 100% of their continuous ampere rating.

9. Ground fault protection shall be provided where indicated on the Drawings.

10. Where indicated on the Drawings, circuit breakers shall be current limiting.

11. Unless specified otherwise, circuit breaker load connections shall be compression style, suitable for copper conductors of the number, size, and type indicated on the Drawings.

B. Molded Case Circuit Breakers with Non-Interchangeable Trip Units

1. Unless specified otherwise, circuit breakers with 100 A frames and below shall be provided with factory installed non-interchangeable trip units.

2. Unless specified otherwise, circuit breakers with non-interchangeable trip units shall be provided with fixed magnetic trip elements.

C. Molded Case Circuit Breakers with Interchangeable Trip Units

1. Unless specified otherwise, circuit breakers with 225 A to 600 A frames shall be provided with interchangeable trip units. Trip units shall be field interchangeable. Factory interchangeable trip units are not acceptable.

2. Circuit breaker magnetic trip element shall be provided with front-mounted, field adjustable trip setting. As a minimum, the adjustable magnetic trip shall provide high, low, and intermediate trip settings.
D. Molded Case Circuit Breakers with Solid-State Trip Units

1. Unless specified otherwise, circuit breakers identified on the Drawings as “main circuit breakers” (located in the main service switchboard, distribution switchboards, or MCCs), or circuit breakers with 800 A frames and above shall have solid-state trip units. In addition, the “main circuit breaker” located in the main service switchboard shall be equipped with ground fault protection.

2. As a minimum the solid-state trip units shall be provided with the following components, features, and capabilities:
   
   a. Microprocessor-based trip device, flux-transfer shunt trip, and three (3) integral current sensors. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors, and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time-delay settings are reached. The trip unit shall be Eaton type Digitrip 310, General Electric type MicroVersaTrip Plus, or approved equal.

   b. An adjustable trip setting dial mounted on the front of the trip unit and interchangeable ratings plugs shall establish the continuous trip ratings of each circuit breaker as a function of the rating plug amperage. Rating plugs shall be field interchangeable. Rating plugs shall be interlocked so they are not interchangeable between frames, and interlocked such that a breaker cannot be closed and latched with the rating plug removed.

   c. As a minimum, system coordination shall be provided by the following microprocessor-based time-current curve shaping features: adjustable long-time setting and delay, adjustable short-time setting and delay, adjustable instantaneous pick-up, adjustable instantaneous setting (pick-up), and where specified, adjustable ground fault setting and delay.

   d. The microprocessor-based trip unit shall have both powered and unpowered thermal memory to provide protection against cumulative overheating should a number of overload conditions occur in quick succession.

   e. When the adjustable instantaneous setting is omitted, the trip unit shall be operate with an instantaneous override.
f. Where internal ground fault protection is specified, adjustable settings shall not exceed 1200 A. Provide neutral ground fault sensor for four-wire loads.

g. Breakers shall have built-in jack located on the front to accept a test cable from a test kit. Provide one portable, battery operated test kit capable of testing all breakers 225 A frame and above. The test kit shall test the circuit breaker while the circuit breaker is carrying load, and shall provide either a trip or no trip test. The test kit shall simulate a time-over current condition for the long-time, short-time and ground fault functions. The test kit shall also read trip unit switch settings and provide a report of the trip unit self-test feature.

h. Where specified herein or indicated on the Drawings, the trip unit shall be provided with an arc-flash reduction maintenance system capability. The arc-flash reduction maintenance system shall allow the operator to enable a maintenance mode using a keyed switch which enables a preset accelerated instantaneous override to reduce arc-flash energy. A LED light on the trip unit shall indicate the trip unit is in the maintenance mode.

E. Insulated Case Power Circuit Breakers

1. Unless specified otherwise, circuit breakers with frame ratings greater than 2,500 A, shall be insulated case power circuit breakers. Insulated case power circuit breakers shall be drawout type. Insulated case power circuit breakers shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.

2. Unless specified otherwise, insulated case power circuit breakers shall be electrically operated. To facilitate lifting, the insulated case circuit breaker shall have integral handles on the side of the breaker.

3. Electrically operated breakers shall be complete with close/open pushbuttons, plus red and green status lights to indicate breaker contact position, and 120 VAC motor operators. The AC source shall be supplied by a control power transformer internal to the panel assembly.
4. Breakers shall have a minimum symmetrical interrupting capacity of 65,000 A at 600 V. Breakers shall be provided with a higher interrupting capacity, if indicated on the Drawings or required by the Contractor’s Electrical Short-circuit and Protective Device Evaluation and Coordination Study. To ensure a selective system, all circuit breakers shall have 30-cycle short-time withstand ratings equal to 18 times their frame ratings. Insulated case circuit breakers without an instantaneous trip element adjustment shall be equipped with a fixed internal instantaneous override set at that level.

5. All insulated case power circuit breakers shall be constructed and tested in accordance with UL requirements, and shall carry a UL label.

6. Each insulated case circuit breaker shall be equipped with a solid-state trip unit. As a minimum the solid-state trip unit shall be provided with the following components, features, and capabilities:

   a. Microprocessor-based trip device, flux-transfer shunt trip, and three current sensors. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached. Interchangeable current sensors with their associated rating plug shall establish the continuous trip rating of each circuit breaker. The trip unit shall be Eaton type Digitrip RMS 520, or equal.

   b. The trip unit shall be provided with individually adjustable time/current curve shaping solid-state elements for protective device coordination, and shall, as a minimum, include: long delay pickup and time, short delay pickup and time, and instantaneous pickup. Unless specified otherwise, trip units provided on insulated case circuit breakers in main service switchboards shall be provided with ground fault protection, including adjustable ground fault current pickup and time. The trip unit shall have provisions for a single test kit to test each of the trip functions.

   c. The trip unit shall be provided with an information system that indicates mode of trip with LEDs following an automatic trip operation. The unit shall also be equipped with a display panel that provides a representation of the time/current curve which shall indicate the protection functions. The unit shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.
d. The solid-state trip unit shall be provided with an arc-flash reduction maintenance system capability. The arc-flash reduction maintenance system shall allow the operator to enable a maintenance mode using a keyed switch which enables a preset accelerated instantaneous override trip to reduce arc-flash energy. A LED light on the trip unit shall indicate the trip unit is in the maintenance mode.

7. The insulated case circuit breaker shall have a closing time of not more than 3 cycles. The primary contacts shall have an easily accessible wear indicator to indicate contact erosion.

8. The insulated case circuit breaker shall have three windows in the front cover to clearly indicate any electrical accessories that are mounted in the breaker. The accessory shall have a label that will indicate its function and voltage. The accessories shall be plug and lock type and UL listed for easy field installation. They shall be modular in design and shall be common to all frame sizes and ratings.

9. The breaker control interface shall have color-coded visual indicators to indicate contact open or closed positions as well as mechanism charged and discharged positions. Manual control pushbuttons on the breaker face shall be provided for opening and closing the breaker. The power circuit breaker shall have a “Positive On” feature. The breaker flag will read “Closed” if the contacts are welded and the breaker is attempted to be tripped or opened.

10. The current sensors shall have a back cover window that will permit viewing the sensor rating on the back of the breaker. A rating plug shall provide indication of the rating on the front of the trip unit.

11. A position indicator shall be located on the faceplate of the breaker. This indicator shall provide color indication of the breaker position in the cell. These positions shall be Connect (Red), Test (Yellow), and Disconnect (Green). The levering door shall be interlocked so that when the breaker is in the closed position, the breaker levering-in door shall not open.
12. Drawout breaker cells shall be equipped with drawout rails and primary and secondary disconnecting contacts. The stationary part of the primary disconnecting devices for each insulated case circuit breaker shall consist of a set of contacts extending to the rear through a glass polyester insulating support barrier; corresponding moving finger contacts suitably spaced shall be furnished on the insulated case circuit breaker studs which engage in only the connected position. The assembly shall provide multiple silver-to-silver full floating high-pressure point contacts with uniform pressure on each finger maintained by springs.

   a. The secondary disconnecting devices shall consist of plug-in connectors mounted on the removable unit and engaging floating plug-in connectors at the front of the compartment. The secondary disconnecting devices shall be gold-plated and pin and socket contact engagement shall be maintained in the “connected” and “test” positions.

   b. The removable insulated case circuit breaker element shall be equipped with disconnecting contacts, wheels and interlocks for drawout application. It shall have four (4) positions: CONNECTED, TEST, DISCONNECTED and REMOVED all of which permit closing the compartment door. The breaker drawout element shall contain a worm gear levering “in” and “out” mechanism with removable lever crank. Mechanical interlocking shall be provided so that the breaker is in the tripped position before levering “in” or “out” of the cell. The breaker shall include an optional provision for key locking open to prevent manual or electric closing. Padlocking shall secure the breaker in the connected, test or disconnected position by preventing levering.

2.05 NAMEPLATES AND PLAQUES

   A. Engraved laminated plastic nameplates shall be provided to identify MCCs, switchboards, panelboards, door mounted components, and internal components. Nameplates shall be mounted on the face of the assembly.

   B. Nameplates shall be 1/16" thick with beveled edges and satin finish. Nameplates shall be provided with black background and white letters. Letters shall be a minimum of 3/16" high. Nameplates shall be fastened with round head stainless steel screws.
C. Nameplates shall be provided for each MCC and each unit compartment. MCC nameplate shall designate: name of manufacturer, system voltage, main bus rating, main bus short-circuit rating, and vertical bus rating. MCC compartment nameplates shall designate the descriptions indicated on the Drawings. Nameplates shall be provided for each pilot device or instrument mounted on the MCC compartment doors. Pilot device nameplates shall be manufacturer's standard style. Device nameplates shall designate the descriptions indicated on the Drawings.

D. Nameplates shall be provided for each switchboard and each circuit breaker and device mounted on front of the switchboard. Switchboard nameplate shall designate: name of manufacturer, system voltage, bus rating, and bus short-circuit rating. Nameplates for the branch circuit breakers shall designate the equipment fed through the breaker.

E. Nameplates shall be provided for each panelboard and transformer. Panelboard nameplate shall designate: system voltage, bus rating, and number of circuits. Transformer nameplate shall designate: primary and secondary voltage, and KVA rating.

F. All nameplates shall be approved by the District prior to fabrication. Contractor shall submit for District approval, a master nameplate spreadsheet, listing: nameplate description (each line), letter height, and nameplate dimensions.

G. A plaque displaying a mimic bus diagram shall be provided for each switchboard. The mimic bus diagram shall be a concise visual presentation of principal switchboard components and connections. The mimic bus diagram shall be arranged in single-line diagram format, using symbols and letter designations consistent with the as-built bus diagram. The mimic bus diagram shall be engraved on an anodized aluminum plaque.

2.06 SPARE PARTS AND ACCESSORIES

A. All spare parts shall be of the same material and workmanship, shall meet the same requirements, and shall be interchangeable with the corresponding original parts furnished. Spare parts shall be properly packaged for shipment and storage, and shall be labeled with the manufacturer's part number(s).

B. As a minimum, Contractor shall furnish the following spare parts:

1. Two (2) fuses of each type and size for three-phase power.

2. Five (5) fuses of each type and size for single-phase power (including control power).

3. One (1) circuit breaker auxiliary switch of each type.

4. Two (2) operating coils for each size AC contactor.
5. Two (2) complete sets of 3-pole stationary and moving contact assemblies for each size AC contactor.

6. Three (3) contactor overload relays of each type and rating, each relay with a complete set of contact blocks.

7. One (1) spare set of heater elements for each heater rating provided.

8. Two (2) indicating light assemblies of each type.

9. One (1) control relay of each type and rating.

10. One (1) contactor auxiliary contact of each type.

11. Two (2) one quart containers of finish paint for indoor MCC and switchboard enclosures. One quart for each, if finish paint differs for MCC and switchboard enclosures.

12. Two (2) one quart containers of finish paint for the outdoor MCC and switchboard enclosures. One quart for each, if finish paint differs for MCC and switchboard enclosures.

13. 4 keys for each type of door lock and keying.

14. Portable test kit(s) for circuit breaker microprocessor trip units to test each of the trip unit functions without removal from the panel. One test kit shall be provided for each type of trip unit supplied.

15. MCC and switchboard accessory sets, including, but not limited to, tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

16. One (1) remote racking device for drawout circuit breakers.

17. One (1) portable, floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments and suitable for the largest circuit breaker furnished.
PART 3 – EXECUTION

3.01 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be performed in accordance with the latest version of ANSI and NEMA standards.

The MCCs and switchboards shall be completely assembled, wired, adjusted and tested at the factory. After assembly, the complete MCCs and switchboards shall be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2200 volts for one minute between live parts and ground and between opposite polarities. The wiring and control circuits shall be given a functional test at rated voltage.

B. The manufacturer shall provide three (3) certified copies of factory test reports to District for approval prior to shipment.

3.02 INSTALLATION

A. Contractor shall install all equipment in accordance with the manufacturer’s written instructions, NEC standards, requirements and standards specified herein, and as indicated on the Drawings.

B. Each assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position.

C. Contractor shall anchor MCCs and switchboards to reinforced concrete pads and floor slabs in accordance with the calculations and details prepared by the manufacturer's engineer. Anchor bolt embedment depth shall be based on the thickness of the structure slab only, and shall not include any portion of the raised concrete housekeeping pad beneath the equipment.

D. Verify the compatibility of conductor size, type, and stranding versus the power lugs furnished. Utilize correct lugs in all applications. Crimp compression lugs with manufacturer recommended tools.

E. Support incoming line conductors and outgoing load conductors to withstand the effects of a fault current. Support (brace) incoming and outgoing conductors in accordance with the manufacturer's written requirements and per NEC, including brace material and spacing.
F. Tighten all bus splices, lugs, connectors, terminals, etc. in accordance with the equipment manufacturer's published torque tightening values for same.

G. Perform all pre-energizing checks as recommended by the manufacturer, including, but not limited to, the following:

1. Verify field wiring for proper conductor sizing.
2. Verify field wiring connection points with the Drawings and manufacturer's electrical schematics.
3. Verify the integrity of all field connections, including proper torqueing of connections.
4. Verify field connections for proper spacing between adjacent phases and/or phases to ground.
5. Verify proper support (bracing) of all incoming and outgoing conductors.
6. Verify that all ground connections have been properly made, including: ground bar connections to facility grounding system, and ground conductor connections to equipment or facility grounding systems.
7. Verify that all barriers and parts that may have been removed during installation have been re-installed.

3.03 FIELD QUALITY CONTROL

A. Contractor shall provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in installation and start-up of the equipment specified under this Section. The manufacturer's representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

B. The following minimum work shall be performed by the Contractor under the technical direction of the manufacturer's service representative.

1. Rig the assembly into final location and install on level surface.
2. Check all removable circuit breakers and starter units for easy removal and re-insertion.
3. Perform insulation tests on each power phase and verify low resistance ground connection on ground bus.

4. Connect all power wiring and control wiring and verify basic operation of each starter from control power source.

5. Torque all bolted connections made in the field and verify all factory bolted connections.

6. Calibrate any solid-state metering or control relays for their intended purpose and make written notations of adjustments on record drawings. Perform startup of any solid-state starters and variable frequency drives.

3.04 FIELD ADJUSTMENTS AND TESTING

A. Contractor shall perform all equipment field adjustments and testing in accordance with the manufacturer’s written instructions and Contract Document requirements, including, but not limited to: short-circuit protective device settings, overload relay settings, timing relays, and startup and testing.

B. Contractor shall coordinate and set circuit breaker tripping sequence from main service protective device to individual motors.

C. MCCs, switchboards, and panelboards shall be tested as stipulated in the NETA testing procedures for same and as specified in Section 16010.

D. Contractor shall prepare formal field reports on all tests performed, providing a written description of each test, test values recorded, parameter limits, deficiencies, equipment adjustments, etc., and shall provide same to District for review and approval.

3.05 MANUFACTURER’S CERTIFICATION

A. A qualified factory-trained manufacturer’s representative shall certify in writing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer’s recommendations. Equipment shall be inspected prior to the performance of field testing and the generation of any reports.

B. Manufacturer’s written certification shall be provided in accordance with Section 16010.
3.06 CLEANUP

A. All parts of the electrical equipment and materials shall be left in a clean condition. Exposed parts shall be clean of dust, dirt, cement, plaster and other materials, and all oil and grease spots shall be removed with a non-flammable cleaning solvent. Such surfaces shall be carefully wiped and cleaned. Paint touch-up shall be applied to all scratches on panels and cabinets. Electrical cabinets or enclosures shall be free of spider webs.

B. Paint touch-up matching factory color and finish shall be applied to all scratches on panels and cabinets.

3.07 INSTRUCTION

After the equipment has been installed, tested, and adjusted, and placed in satisfactory operating condition, the equipment manufacturer shall provide classroom instruction to District's personnel in the use and maintenance of the equipment. Four (4) hours of instruction shall be provided unless otherwise specified. Contractor shall give the District formal written notice of the proposed instruction period at least two weeks prior to commencement of the instruction period. Scheduled training shall be at a time acceptable to the District and the manufacturer. During this instruction period, the manufacturer shall answer any questions from District personnel. The manufacturer's obligation shall be considered ended when he and the District agree that no further instruction is needed.
MCCs, Switchboards, and Panelboards
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SECTION 16640
CORROSION MONITORING SYSTEM FOR UNDERGROUND PIPING

PART 1 - GENERAL

1.01 DESCRIPTION
Construct corrosion monitoring system for the pipeline by installing test stations as shown on the drawings and as specified herein.

1.02 SUBMITTAL
Submit catalog data on test boxes, wire, copper sulfate reference cells, thermite welds, and weld coating.

PART 2 - PRODUCT

2.01 TEST BOXES
Each test station enclosure shall be a concrete valve box with a cast iron cover marked “EMWD CPT”. Test stations shall be Brooks Products valve box 1-RT or approved equal through EISEL Enterprises or J & R Concrete Products.

2.02 WIRE
Copper-Copper Sulfate (CSE) reference electrodes lead wires are specified under “Reference Electrodes” below. Other wiring to be copper of the size shown and shall have THWN insulation of the color shown. Dyed insulation is not acceptable.

2.03 REFERENCE ELECTRODES
Reference electrodes shall be copper-copper sulfate (CSE) suitable for direct burial. They shall be designed to remain stable for at least twenty years. The reference cell shall be capable of maintaining a potential within 15 millivolts of a freshly made cell while draining 2 microamperes. Reference cells shall contain a barrier to inhibit migration of chloride ions from the soil into the reference cell. Reference cell lead wire shall be #14 AWG copper, with yellow RHW insulation and shall be silver soldered to the copper core of the reference cell with the connection epoxy sealed by the manufacturer. CSEs shall be Stelth 2 by Borin Manufacturing, Staperm Model CU-1-UGPC by GMC Corrosion, or equal.
2.04 THERMITE WELDS
Thermite weld shall be “Cadweld” by Erico Products, “Thermoweld” by Continental Industries, Inc., or equal. Mold shall be the type recommended by the manufacturer for the wire size, metal shape, and orientation. Weld alloy shall be formulated for use on steel or iron pipe as appropriate and shall be of the weight recommended by the manufacturer for the size cable and mold being used. Welds to be buried or submerged shall be primed with an elastomer resin based primer then be covered with a 100% solids mastic filled plastic cap or cement-mortar. Use the plastic cap on dielectric coated pipe following the manufacturer’s instructions. Use cement-mortar on cement-mortar coated pipe. Primer and cap shall be Roybond Primer 747 and Handy Cap as manufactured by Royston Laboratories, or equal.

PART 3 - INSTALLATION

3.01 REFERENCE CELLS
Install reference cells as detailed on the drawings. Backfill around each reference cell and compact to the relative compaction specified in Section 02201 taking care not to damage the reference cell. Coil the reference cell wire in slack loops to compensate for settlement both near the cell and near the cathodic test station. Any damage to the insulation on the reference cell wire shall be wrapped with two layers of Scotch No. 88 vinyl electrical tape or equal. Wet the reference cell and backfill per the manufacturer’s instructions.

3.02 THERMITE WELD
Clean pipe to bright metal. Weld according the manufacturer’s instructions. Test completed weld by striking the side of the weld solidly with a 16 ounce or larger hammer. Remove flux and coat as specified above.

3.03 SPLICE
Splices shall be made only where shown or allowed. Splices shall be made using split bolt connectors or crimp connectors of the smallest size compatible with the cables being used. Connections shall be insulated with two half lapped layers of rubber tape and at least one half lapped layer of plastic tape, by encasing in resin (3M Scotchcast), heat shrink sleeve (Raychem ASE), or equal.

3.04 TESTING PROCEDURES FOR COMPLETED TEST STATIONS AND JOINT BONDS After the pipeline is backfilled test each test station and joint bonds for effectiveness using the procedures described below. The testing and report shall be completed by or under the direction of a California licensed corrosion engineer or NACE International Certified Cathodic Protection Specialist.

Measure native pipe-to-soil potentials to a portable CSE using each wire at each test station and to the stationary CSE where installed. Repair or replace any wires or test stations that are not operating properly and remeasure to confirm proper operation. Record the data in clear tabular form.
Test to determine if the joint bonds are effective using a temporary cathodic protection system. Measure pipe-to-soil potentials at test stations at the ends of the pipe and other locations as necessary to confirm electrical continuity with cathodic current applied and immediately after turning the current off. Installer shall repair all discontinuities found. Repaired test station shall be retested until continuity is established throughout the installed piping. Record the potentials and currents.

During the corrosion monitoring system test described above, measure pipe-to-soil potentials on both sides of each insulated joint to determine its effectiveness. If defective insulated joints are found, repairs shall be made by the installer. Retests and measurements shall be reported until all insulated joints are proved effective.

Submit a written report with test data, conclusions, and any recommendations signed by licensed corrosion engineer or cathodic protection specialist.

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PART 1 - GENERAL

1.01 DESCRIPTION

Contractor shall furnish and install custom control panels as specified herein, shown on the Drawings, and where specified in other Specification Sections.

A. Custom control panels include, but are not limited to, Unit Control Panels (UCPs), Local Control Panels (LCPs), and Programmable Logic Controllers (PLCs). Custom control panels include control panels designed and supplied by equipment manufacturers as part of packaged equipment and equipment systems.

B. The Instrumentation and Control Subcontractor (per Section 17005) shall design or review design of custom control panels and coordinate the interface between custom control panels, MCCs, other control panels, instrumentation, and District’s SCADA system (including remote telemetry units, RTUs).

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the Contractor and its Subcontractors to review all sections to ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Sections of the Specifications specifying equipment and/or systems requiring electrical power and/or control.

2. Division 16 – Electrical

3. Division 17 – Instrumentation and Controls

1.03 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.
A. **Shop Drawings**

Contractor shall prepare and submit complete and organized information, drawings, and technical data for all equipment and components. All drawings shall be legible and reduced to a maximum size of 11” x 17” for inclusion within the submittal. Shop drawings shall include, but not be limited to, the following:

1. Detailed Bill of Materials for all control panel hardware, and associated materials and components, listing: manufacturer’s name, quantity, description, size, and catalog/part number.

2. Complete documentation for all control panel equipment and associated components, including: manufacturer’s product literature, specifications, performance capabilities, features and accessories, dimensions and weights, illustrations, and data in sufficient detail to demonstrate compliance with Specification requirements. Manufacturer’s literature and data shall be marked to clearly delineate all applicable information and crossing out all inapplicable information.

3. Control panel fabrication drawings (plan view, and interior and exterior elevation views) with all equipment and components clearly shown, dimensioned, and labeled. Drawings shall show the equipment and component assembly, clearances, and locations for conduits/conductors and anchor bolts. Devices shall be identified with the same marking as used on the schematic diagrams. The drawings shall include a detailed layout of all door mounted pilot devices and instruments.

4. Enclosure construction, NEMA Type, and type and gauge of materials.

5. Detailed descriptions of control panel equipment, equipment installation requirements, and heat dissipations.

6. System configuration with power circuit single line diagrams, grounding circuits, circuit breakers, and fuses.

7. Control schematics, ladder diagrams, and interconnection drawings (see Part 1.03.B herein) for additional requirements.

8. Nameplate data including the nameplate material, heights of letter and inscriptions.

9. Spare parts list as specified in this Section.
10. Manufacturer's installation instructions including receiving, handling, and storage requirements.

B. Control Diagrams

1. Schematic diagrams shall show the equipment serial number, the purchaser's drawing number, purchase order number, or similar identification which will indicate the particular equipment to which the diagrams apply.

2. Diagrams shall show all equipment and components in the electrical system including internal wiring of subassemblies. Diagrams shall clearly identify internal and external devices, and all remote contacts and signals. Show all interconnections between power sources and device elements of a particular system or equipment, and all interlocks with other equipment/systems in a manner that fully indicates the circuit function and operation. Show all panel terminal block identification numbers and all wire numbers. Show all intermediate terminations between field elements and panels. Diagrams of subassemblies may be furnished on separate sheets.

3. Identify each device by a unique number or number-letter combination.

4. Conductor Identification: Identify each conductor by a unique number, letter, or number-letter combination. Consecutive numbering is preferred. Each conductor shall have the same identification at all terminals and tie points. All conductors connected to the same terminal or tie point shall have the same identification. Where multi conductor cable is used, a color code may be used to supplement the above identification. Where color coded multi conductor cable is used for wiring identical components, such as limit switches, the color code used shall be consistent and charted on related diagrams.

5. Provide a schematic diagram for each electrical system. The schematic diagram shall be drawn between vertical lines which represent the source of control power. Show control devices between these lines. Show actuating coils of control devices on the right-hand side. Show contacts between the coils and the left vertical line.

a. Where the internal wiring diagrams of subassemblies are furnished on separate sheets, they shall be shown as a rectangle in the schematic diagram with all external points identified and cross-referenced to the separate sheets of the control circuit. Show coils and contacts internal to the subassemblies in the rectangle connected to their terminal points.

b. For clarity, show control device symbols in the order in which the controls are positioned on the diagram.
c. Use a cross-referencing system in conjunction with each relay coil so that associated contacts may be readily located on the diagram. Where a relay contact appears on a sheet separate from the one on which the coil is shown, describe the purpose of the contact on the same sheet.

d. Show all spare contacts.

e. Show limit, pressure, level, flow, temperature, and similar switch symbols on the schematic diagram with all utilities turned off (electric power, air, gas, oil, water, lubrication, etc.) and with the equipment at its normal starting position.

f. Show contacts of multiple contact devices (e.g., selector switches and pushbuttons) on the line of the schematic diagram where they are connected in a circuit. Indicate a mechanical connection between the multiple contacts by a dotted line or arrow.

g. Additional charts or diagrams may be used to indicate the position of multiple contact devices such as limit, pressure, level, and selector switches.

h. Show the purpose or function of all switches adjacent to the symbols.

i. Show the purpose or function of controls such as relays, starters, contactors, solenoids, subassemblies, and timers on the diagram adjacent to their respective symbols. Show the number of positions of the solenoid valve adjacent to the valve solenoid symbol.

C. **Operation and Maintenance Manual**

Contractor shall submit a detailed Operation and Maintenance (O&M) Manual for all custom control panels specified herein and shown on the Drawings. The O&M Manual shall be provided in accordance with the requirements of the District's General Conditions, Specification Section 01430, and as specified herein.

The O&M Manual shall include, but not be limited to, the following:

1. **Equipment Performance Data and Drawings**

   a. Detailed Bill of Materials for all control panel equipment and components, listing: manufacturer's name, quantity, description, size, range, and model/part number.
b. Manufacturer's product literature, specifications, performance capabilities, features and accessories, and illustrations.

c. Manufacturer’s data and drawings showing dimensions, physical configurations, installation and mounting details, and wiring schematics.

d. Control ladder diagrams and wiring schematics. Loop diagrams for each monitoring and/or control loop.

2. Installation and Operation Requirements

a. Complete, detailed installation and operation instructions for all control panel equipment and components.

3. Service and Maintenance Data

a. Service and maintenance data shall include all information and instructions required by District’s personnel to keep the control panel and all associated components functioning properly under the full range of operating conditions.

b. Explanation with illustrations as necessary for each service and maintenance task.

c. Recommended schedule of service and maintenance tasks.

d. Troubleshooting instructions.

e. List of maintenance tools and equipment.

f. Recommended spare parts list.

g. Names, addresses and phone numbers of all manufacturers and manufacturer's local service representatives.

D. Final O&M Manual

Upon successful completion of startup and initial operation, Contractor shall submit a Final O&M Manual in accordance with the requirements of the District’s General Conditions, Specification Section 01430, and as specified herein. In addition to the O&M Manual requirements specified above, the Final O&M Manual shall be supplemented with the as-built drawings (including all field changes) for all control panel wiring and loop diagrams.
1.04 DESIGN AND GENERAL REQUIREMENTS

A. Power for Control Panels and Interconnected Devices

1. All control panels shall be supplied with 480 VAC, 3-phase, 240 VAC Single Phase or 120 VAC Single Phase 60 Hz. power, as shown on the Drawings. All control panels shall be designed to minimize sources of control power (foreign power) from other panels.

2. Each control panel shall have a flange mounted disconnecting circuit breaker operable from the control panel front and interlocked with the enclosure door, to be used to isolate the control panel from the power supply.

3. The panel shall have a nameplate identifying the circuit breaker feeding the panel. Warning labels shall be provided identifying sources of foreign power to be disconnected prior to accessing the control panel.

4. The control voltage within the control panel controls shall be 120 VAC. Where the electrical power supply to the control panel is 240 VAC single phase or 480 VAC 3-phase, as shown on the Drawings, the control panel shall be provided with control power transformers, overcurrent protection, and power supplies to convert supply voltage to utilization voltage.

5. The control panel shall be the source of power for all 120 VAC devices interconnected with the control panel including, but not limited to solenoid valves, instruments, and transmitters both mounted in the control panel and remotely connected to the control panel.

B. Enclosure General Requirements

Unless indicated otherwise on the Drawings, or in the individual packaged equipment specification sections, control panels shall comply with the following requirements:

1. Control panels enclosures shall meet, or exceed, area classifications requirements per NEC.

2. Control panel enclosures shall have the following NEMA ratings:
   a. Enclosures installed indoors shall be rated NEMA 12.
   b. Enclosures installed outdoors shall be rated NEMA 4X.
   c. Enclosures installed indoors in wet or corrosive areas shall be rated NEMA 4X.
d. Enclosures installed indoors in hazardous areas shall be rated NEMA 7.

e. Enclosures installed outdoors in hazardous areas shall be rated NEMA 4 and NEMA 7.

3. Control panels shall be either freestanding, pedestal-mounted, wall-mounted, or equipment skid-mounted, as specified in the individual packaged equipment specification sections or indicated on the Drawings.

4. Internal control components shall be mounted on an internal back-panel.

5. Each source of foreign control voltage shall be isolated by providing fuses on a separate terminal block, clearly labeled for incoming foreign control voltage.

6. Discrete outputs from the control panel shall be provided by electrically isolated contacts rated for 5 A (minimum) at 120 VAC. Output isolation shall be provided through interposing relays or PLC relay output cards (if applicable).

7. Analog inputs and outputs shall be an isolated 4-20 mA 2-wire signal with power supply, power supply pilot light, and fuses.

8. Programmable Logic Controllers (PLCs) may be supplied in lieu of hardwired relay logic with the District's approval or if specified in the specification section for the specific equipment. The PLC shall be in accordance with Section 17010, Programmable Logic Controller.

9. All control panel mounted indicating lights, switches, and operator interface devices shall be mounted at least 3 feet above the finished floor elevation, but no more than 6 feet above the finished floor elevation.

10. Terminals shall be mounted vertical and locations of terminals and wireways shall be coordinated to account for conduit entrances.

11. Control panels that contain circuit breakers, combination full-voltage motor starters, soft starters, variable frequency drives, or other motor controls shall comply with the requirements Section 16480, Motor Control Centers, Switchboards, and Panelboards, and Section 16160, Variable Frequency Drives.
1.05 QUALITY ASSURANCE

A. References

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

B. Unless specified otherwise, references to documents shall mean the documents in effect at the time of Bid (or on the effective date of the Agreement if there were no bids).

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFPA 70</td>
<td>National Electrical Code (NEC)</td>
</tr>
<tr>
<td>NFPA 70E</td>
<td>Standard for Electrical Safety in the Workplace</td>
</tr>
<tr>
<td>NFPA 79</td>
<td>Electrical Standard for Industrial Machinery</td>
</tr>
<tr>
<td>NEMA 250</td>
<td>Enclosures for Electrical Equipment (1000 Volts Maximum)</td>
</tr>
<tr>
<td>NEMA ICS 6</td>
<td>Industrial Control and Systems: Enclosures</td>
</tr>
<tr>
<td>UL 508A</td>
<td>Industrial Control Panels</td>
</tr>
<tr>
<td>UL 698A</td>
<td>Industrial Control Panels Relating to Hazardous (Classified) Locations</td>
</tr>
</tbody>
</table>

Assembly:

1. The assembled panels and individual components shall be Underwriters Laboratory (UL) listed and labeled.

2. Equipment and components shall be UL listed for the proposed purpose.

3. The control panels shall have factory applied UL 508A labels.

4. The intrinsic safety barriers required within a control panel shall be provided per UL 698A with factory applied labels as required by UL.

C. Factory Testing

Prior to shipment, the manufacturer shall test the functional operation of the control panels as specified in Part 3.01 herein.
D. Environmental Sustainability

1. All indoor and outdoor panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents.

2. Unless specified otherwise, heating, cooling and dehumidifying devices shall be provided in order to maintain all instrumentation components to within a range equal to 20 percent above the minimum and 20 percent below the maximum of the rated environmental operating ranges. All required power wiring and temperature controls shall be provided for these devices.

3. Enclosures suitable for the designated environment shall be furnished.

4. All control panels and instrumentation enclosures in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Delivery

All control panels shall be crated for shipment using heavy framework and skids:

1. Each panel shall further be cushioned satisfactorily to protect the finish of the instruments and panel during shipment.

2. All instruments, which are shipped with the panel, shall further have suitable shipping stops and cushioning material installed in a manner to protect instrument parts, which could be damaged due to mechanical shock during shipment.

3. Large panel units and/or panel units weighing over 100 lbs. shall be provided with removable lifting lugs to facilitate handling.

B. Storage and Handling

Control panels shall be stored and handled in accordance with the manufacturer's instructions and requirements and in a manner to protect the panel from the elements. Panels shall be handled in a manner to protect the components and enclosures.
PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Control panel enclosures shall be standard manufactured enclosures, whenever possible, and shall be as manufactured by Hoffman Engineering, Rittal, Stalin, or equal.

B. Dimensions

1. The Instrumentation and Control Subcontractor (ICS) and/or manufacturer of the packaged equipment system shall be responsible to design and size all panel enclosures based upon:

   a. Available space in area, as indicated on the Drawings.

   b. Equipment and device requirements for components located within the control panel enclosure.

2. The size of the control panel enclosures as indicated on the Drawings is based on preliminary, non-certified, information and as such these sizes are to be used as a general guideline.

3. A narrow or wide panel enclosure shall be provided if necessary to accommodate the available space. A larger enclosure shall be provided if necessary to accommodate the equipment, devices, and appurtenances located within the panel.

2.02 MANUFACTURED ENCLOSURES

A. Type NEMA 1 and NEMA 12 Enclosures for Indoor Installation

1. Unless specified otherwise, enclosures rated NEMA 12 shall be provided for all indoor panels located in dry, non-corrosive areas. Where panels are located in dry, non-corrosive areas and are required to be ventilated for cooling (fan or non-fan cooled), enclosures shall be rated NEMA 1 gasketed.

2. NEMA 1 gasketed enclosures shall be designed to house electrical controls, terminals, and instruments and shall provide protection from dust and dirt.

3. NEMA 12 enclosures shall be designed to house electrical controls, terminals, and instruments, and shall provide protection from dust, dirt, and oil.
4. Enclosure minimum construction requirements shall be as follows:

a. Seams continuously welded and ground smooth.

b. Door and body stiffeners as needed to make a rigid enclosure.

c. Heavy gauge continuous hinge.

d. Rolled lip around 3 sides of the door and all sides of the enclosure opening to prevent migration of liquids and contaminants into enclosure.

e. Oil-resistant gasket attached to door with oil-resistant adhesive. Gasket to seal against roll lip on the enclosure opening.

f. Interior back panel held in place by collar studs welded to enclosure. Back panel shall be full size, constructed of 10 gauge steel with stiffeners as required. Provide split back panel where specified or indicated on the Drawings.

g. Door window where specified or indicated on the Drawings:

i) Safety plate glass.

ii) Held in place by rubber locking seal.

iii) Sized to allow full view of alphanumeric display, operator interface, PLC Human-Machine Interface (HMI), etc.

h. Door panel cutouts for instruments, devices, and windows shall be cut, punched, or drilled and smoothly finished with rounded edges. Reinforce around cutouts with steel angles or flat bars for large panel cutouts such as for HMIs and for pilot device groupings where the removed metal exceeds 50 percent of the available metal in an area bound by a 3-inch envelope around said pilot devices.

i. Finish for NEMA 1 and NEMA 12 Enclosures

i) All steel parts shall be provided with UL listed acrylic/alkyd baked enamel paint finish or TGIC powder coat, except plated parts used for ground connections. All painted parts shall undergo a multi-stage treatment process, followed by the finishing paint coat.
ii) Pre-treatment shall include:

a) Hot alkaline cleaner to remove grease and oil.

b) Iron phosphate treatment to improve adhesion and corrosion resistance

iii) The paint shall be applied using an electro-deposition process to ensure a uniform paint coat with high adhesion.

iv) The standard paint finish shall be tested to UL 50 per ASTM B117 (5% ASTM Salt Spray) with no greater than 0.125 inch loss of paint from a scribed line.

v) Paint color for enclosures shall be #49 medium light gray or #61 dark gray per ANSI Standard Z55.1 (60-70 gloss) on all exterior surfaces, unless specified otherwise. All unit interior surfaces shall be painted white for better visibility inside the unit.

vi) Panels that are in the same room as motor control centers switchboards, etc. shall be of the same color as the motor control center or switchboards so that the control panel blends into the lineup.

j. Manufacturer's standard gauge steel.

k. Each door to have a three-point latching mechanism and padlocking handle with rollers on the ends of the latch rods.

l. Print pocket inside door which shall be furnished with final as-built wiring diagrams and all applicable manufacturer warranties.

m. Heating and cooling per Part 1.05.D and Part 2.04 herein.

n. Heavy duty lifting eyes for all free standing panels.

o. Free standing, wall mount, or with floor stands or legs as indicated on the Drawings.

p. With flange mounted, disconnect for incoming power.

q. Hinges: steel piano-type running full length of doors.
r. Copper ground bus bar 1/4-inch x 1-inch with solderless connectors for all equipment grounds.

s. Bonding and grounding kit, including all cable and mounting hardware required to ground equipment to the door and body of the enclosure.

B. Type NEMA 4X Enclosures for Outdoor and Indoor (Wet or Corrosive Locations) Installation

1. Unless specified otherwise, enclosures rated NEMA 4X shall be provided for all outdoor panels and indoor panels located in wet, corrosive areas.

2. NEMA 4X enclosures shall be designed to house electrical controls, terminals, and instruments and shall provide protection from dust, dirt, oil, water, and corrosion.

3. In general, NEMA 4X enclosures shall be constructed of stainless steel. NEMA 4X enclosures constructed of non-metallic fiberglass reinforced polyester resin shall be provided only where specifically indicated on the Drawings or specified in individual specification sections for packaged equipment systems.

4. Minimum construction requirements for stainless steel enclosures shall be as follows:

   a. Type 316 stainless steel, 14-gauge minimum.

   b. Seams continuously welded and ground smooth.

   c. Door and body stiffeners as needed to make a rigid enclosure.

   d. Heavy gauge continuous hinge.

   e. Rolled lip around three sides of the door and all sides of the enclosure opening to prevent migration of liquids and contaminants into enclosure.

   f. Oil-resistant gasket attached to door with oil-resistant adhesive. Gasket to seal against roll lip on the enclosure opening.

   g. Interior back panel held in place by collar studs welded to enclosure. Back panel shall be full size, constructed of 10 gauge steel with stiffeners as required. Provide split back panel where specified or indicated on the Drawings.
h. Unless specified otherwise or indicated otherwise on the Drawings, panels shall be provided with interior swing-out door for:

i) Mounting switches, lights, devices, and HMI’s.

ii) A window shall be provided in the exterior door for view of interior lights, devices, and instruments if indicated on the Drawings.

i. Door panel cutouts (exterior and swing-out doors) for instruments, devices, and windows shall be cut, punched, or drilled and smoothly finished with rounded edges. Reinforce around cutouts with steel angles or flat bars for large panel cutouts such as for HMI’s and for pilot device groupings where the removed metal exceeds 50 percent of the available metal in an area bound by 3-inch envelope around said pilot devices.

j. Door window where specified or indicated on the Drawings:

i) Safety plate glass.

ii) Held in place by rubber locking seal.

iii) Sized to allow full view of alphanumeric display, operator interface, PLC Human-Machine Interface (HMI), etc.

k. Finish:

i) Stainless steel surfaces shall be unpainted and provided with a brushed finished.

ii) Interior steel parts shall be finished per Part 2.02.A.4.i herein. Finish paint color shall be white (60-70 gloss).

l. Each door to have a three-point latching mechanism and padlocking handle with rollers on the ends of the latch rods.

m. Print pocket inside door which shall be furnished with final as-built wiring diagrams and all applicable manufacturer warranties.

n. Heating and cooling per Part 1.05.D and Part 2.04 herein.

o. Heavy duty lifting eyes for all free standing panels.
Custom Control Panels
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p. Free standing, wall mount, or with floor stands or legs as indicated on the Drawings.

q. With flange mounted, disconnect for incoming power.

r. Hinges: steel piano-type running full length of doors.

s. Copper ground bus bar 1/4-inch x 1-inch with solderless connectors for all equipment grounds.

t. Bonding and grounding kit, including all cable and mounting hardware required to ground equipment to the door and body of the enclosure.

5. Minimum construction requirements for non-metallic enclosures shall be as follows:

a. Shall meet the applicable requirements herein for stainless steel enclosures plus the following additional requirements.

b. Non-metallic enclosures shall be molded fiberglass reinforced polyester resin with plate steel reinforcing on the sides, top, and bottom. The fiberglass reinforced polyester resin shall meet the following minimum standards:

   i) Minimum flexural strength of 29,000 psi per ASTM D790.

   ii) Maximum water absorption of 0.07% per ASTM D570.

   iii) Minimum tensile strength of 17,500 psi per ASTM D651.

   iv) Heat distortion at 400°F per ASTM D648.

   v) Minimum specific gravity of 1.35 per ASTM D792.

   vi) Minimum dielectric strength of 400 V/mil per ASTM D149.

   vii) Minimum arc resistance of 180 seconds per ASTM D495.

   viii) Flammability of 94V-O per ASTM D3801 and UL-94.

c. All seams shall be sealed.

d. Hinges shall be constructed of fiberglass with no exposed metal parts.
e. No exposed metal parts, except for captive stainless steel door screws which shall be replaceable.

f. Provisions for mounting panels shall be an integral part of the enclosure whether by way of internal mounting channels welded to the interior or by way of spot-welded collar studs.

g. Panel exterior gelcoat shall be UV light resistant and shall be light gray in color.

h. Each panel shall be provided with a stainless steel door hasp suitable for padlocking.

i. Enclosure mounting panels shall be constructed of 1/4” thick (minimum) aluminum plate with rounded corners and no sharp edges. Aluminum shall be provided with a uniform brushed finish.

2.03 ENCLOSURE LIGHTS AND RECEPTACLES

A. Each control panel shall be provided with LED lighting fixtures of sufficient size and quantity to provide 50 foot-candles of illumination within the panel. The lighting fixtures shall be horizontal LED tube type fixtures and shall be mounted to the top of the enclosure. The light fixtures shall be wired to a UL-approved switch mounted inside the panel.

B. Each control panel shall be provided with a duplex, 120VAC, 15A, 3-wire grounded GFCI type convenience receptacle.

C. The light fixture(s) and receptacle shall be provided with power by a control transformer in the panel or by a separate 120 VAC circuit, if indicated on the Drawings.

2.04 ENCLOSURE HEATING AND VENTILATION

A. Control panel enclosures shall be provided with heating and ventilation designed by the manufacturer to meet the following requirements and Part 1.05.D herein.

1. Space heaters shall be provided to prevent condensation. Space heaters shall operate on 120 V, 60 Hz power. Adjustable line voltage thermostats shall be provided for controlling the space heaters.
2. Non-forced air and forced air ventilation cooling shall be provided as required to maintain the required temperature of the housed equipment. Forced air ventilation shall be provided with supply fans mounted at the bottom of each enclosure section. The bottom door fans shall force fresh air into the enclosure to create a positive internal air pressure; and thereby, forcing out dirt and contaminants, and moving warm air out through ventilation louvers mounted at the top of the doors. A line voltage thermostat shall control the fans based on the panel internal temperature. Door interlock switches shall be provided to turn the fans off when the door is opened.

3. Supply fans shall be provided with air intake openings equipped with fixed louvers and washable aluminum mesh filters.

Ventilation air shall be exhausted through fixed, louvered openings equipped with washable aluminum mesh filters.

Air supply and exhaust openings shall be sized by the control panel manufacturer for the air flow required to maintain the proper inside temperature. All air filters shall be provided with interior door mounted frames allowing easy removal for cleaning.

B. Where necessary or where specified elsewhere, control panels shall be provided with air conditioning to maintain the required temperature for the housed equipment. Control panel air conditioning units shall be provided in accordance with the following requirements:

1. The air conditioning system shall provide closed-loop cooling and shall be sized by the control panel manufacturer based on: heat generated from all panel equipment and auxiliary components operating at full rated capacity, and said equipment operating under maximum ambient temperature conditions.

2. Unless specified otherwise, air conditioning unit shall operate on 115 V or 230 V, single phase, 60 hertz power supplied by the control panel.

3. Air conditioning unit shall be provided with: 16-gauge (minimum) welded steel framework, an efficient and quiet rotary compressor, built-in condensate evaporator, HFC environment friendly refrigerant, and additional corrosion protection for all aluminum, copper, and ferrous metal surfaces.

4. Air conditioning units for indoor control panels shall be furnished with built-in digital temperature controllers. Air conditioning units for outdoor control panels shall be furnished with remote temperature controllers mounted inside the control panel enclosure in an accessible and visible location.
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5. Unless indicated otherwise on the Drawings, the air conditioning unit shall be designed to mount on the side of the control panel enclosure while maintaining NEMA Type 12, 4, or 4X integrity, and shall be furnished with a gasket kit at the interface between the enclosure and air conditioner. Air conditioning units mounted to NEMA Type 4X stainless steel enclosures shall be constructed of stainless steel.

6. Air conditioning unit shall be constructed to allow easy access for maintenance, including easy pull-out air filters. A minimum of three (3) spare replacement air filters shall be provided with each air conditioning unit.

7. Air conditioner units shall be UL listed, and shall be as manufactured by Ice Qube, Inc., or equal.

C. Control power transformers with primary and secondary fuse protection shall be provided as required for proper operation of the enclosure heating and ventilating equipment, unless Drawings show otherwise. Supply voltage shall be 120 VAC and 60 Hz. Separate line voltage thermostats shall be provided for heating and cooling.

2.05 CONTROL DEVICES AND COMPONENTS

A. Control Transformers

If incoming power supply as shown on the Drawings is other than 120 VAC, each control panel shall be provided with a control transformer. Control transformers shall comply with the following requirements:

1. Each control transformer shall be rated 480/120 V or 240V/120V single phase, 2 wire, 60 Hz, and shall conform to the applicable requirements of NEMA ST 1. The transformer shall have adequate volt-ampere capacity for all connected control function loads indicated, plus an additional 20 percent capacity. Transformer capacity shall be increased as required for any additional non-control function loads, such as condensation heaters, ventilation fans, or air conditioning.

2. Each control transformer shall be feed from the load side of the panel or motor controller disconnect. Control transformers rated 480/120 V shall be provided with two primary fuses rated to interrupt 50,000 A (minimum) at 600 V. One transformer secondary lead shall be provided with a time delay, slow-blow fuse rated to interrupt 10,000 A at 250 V, and the other secondary lead shall be grounded. All fuses shall be provided with blown fuse indicators.
Where control circuit power is provided from a source other than a unit transformer (e.g. a lighting panel circuit breaker), the motor controller disconnect shall include an electrical interlock for disconnection of externally powered control circuits.

B. **Control Relays**

Control relays shall be general purpose, electrically operated, magnetically held, plug-in blade or pin style with DIN rail mountable socket and LED indicator. Control relays shall be UL listed with 10 A rated contacts (thermal continuous current at 120 VAC), and shall be provided with 120 VAC coils, unless specified otherwise. Number of poles and pole arrangement shall be as indicated on the Drawings and as specified herein. Control relays shall be as manufactured by Allen-Bradley, IDEC, OMRON, Potter-Brumfield, or equal.

C. **Time Delay Relays**

Time delay relays shall be general purpose, multi-range, multi-function plug-in blade or pin style with DIN rail mountable socket and LES indicators (timing and timed out). Time delay relays shall be provided with multiple programmable timing ranges (0.5 sec to 24 hours, minimum) and multiple operating modes. As a minimum, relay operating modes shall include: on-delay, off-delay, repeat cycle off start, repeat cycle on start, and signal on/off delay. Time delay relays shall be UL listed with 5 A rated contacts (thermal continuous current at 120 VAC) non-inductive load, and shall be provided with 120 VAC coils, unless specified otherwise. Number of poles, pole arrangement, and maximum timing adjustment shall be as indicated on the Drawings and as specified herein. Time delay relays shall be as manufactured by Allen-Bradley, IDEC, OMRON, Potter-Brumfield, or equal.

D. **Elapsed Time Meters**

Elapsed time meters shall be electromechanical, NEMA Type 4X rated, with rectangular or round case suitable for flush panel mounting. Each meter shall have 6-digit (minimum) registers with counter numbers at least 3 mm high, and shall be non-resetable. White counter numbers on black backgrounds shall provide hour indication with the last digit in contrasting colors to indicate tenths of an hour. Each meter shall operate on 120 VAC input power. Elapsed time meters shall be as manufactured by Eaton, Honeywell/Hobbs, or equal.

E. **Pilot Devices**

1. Pilot devices consisting of pushbuttons, selector switches, pilot lights, and incidental items shall be as manufactured by Allen-Bradley, Eaton/Cutler Hammer, or Schneider/Square D (no substitutes).
2. Pilot devices shall be suitable for mounting on MCCs, switchgear, control panels, and control stations. Pilot devices shall be 30.5 mm, NEMA Type 4/13 with cast metal bases, chrome-plated octagonal mounting nuts, and legend plates.

3. Contact blocks shall have AC contact ratings of NEMA A600, 10 A with silver contacts for corrosion resistance and clear side plates for contact inspection.

4. Pushbuttons and switch knobs shall be heavy duty plastic. Unless indicated otherwise on the Drawings, switch knobs shall be black and pushbuttons shall colors shall be as follows:

<table>
<thead>
<tr>
<th>Color</th>
<th>Function</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Emergency Stop, Stop, Off</td>
<td>Emergency Stop button, Master Stop button, Stop of one or more motors</td>
</tr>
<tr>
<td>Yellow (Amber)</td>
<td>Return, Emergency Return, Intervention (suppress abnormal conditions)</td>
<td>Return of machine to safe position, override other functions previously selected</td>
</tr>
<tr>
<td>Green</td>
<td>Start-On</td>
<td>General or machine start. Start of cycle or partial sequence.</td>
</tr>
<tr>
<td>Black</td>
<td>No specific function assigned</td>
<td>Permitted to be used for any function except for those listed above.</td>
</tr>
</tbody>
</table>

5. Pilot light devices shall be push-to-test type and shall be provided with LEDs and transformers suitable for operation on 120 VAC power. Pilot light lenses shall be shatter resistant plastic. Unless indicated otherwise on the Drawings, pilot light lens colors shall be as follows:

<table>
<thead>
<tr>
<th>Color</th>
<th>Function</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Fail or Alarm (abnormal condition requiring immediate attention)</td>
<td>Indication that a protective device has stopped the machine, e.g. overload</td>
</tr>
<tr>
<td>Yellow (Amber)</td>
<td>Warning (marginal condition, change or impending change of conditions)</td>
<td>Some value (e.g. pressure) is approaching its permissible limits. Overload permitted for a limited time. Ground fault indication.</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Color</th>
<th>Function</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Normal Condition, Confirmation</td>
<td>Normal pressure. Control power on.</td>
</tr>
</tbody>
</table>

F. Mounting of Instruments

1. Provide cutouts, and door mount all instrument items indicated on the Drawings or specified to be panel mounted, including any instruments specified to be furnished by other vendors but installed in panel (if applicable).

2. Mount, behind panel doors, other instrument accessory items as required and/or specified.

3. The rear of panel mounted equipment shall be installed with due regard to commissioning adjustments, servicing requirements and cover removal.

4. Spare space shall be kept clear of wiring, etc. to give maximum space for future additions.

G. Door Mounted Device Shield

Provide a clear acrylic glass (Plexiglass) shield to cover back of door mounted devices (lights, switches, OIT, etc.). Plexiglass shield shall be 1/8" thick and shall be mounted to the panel door (outer door and/or inner swing-out door) with 1/4" diameter stainless steel bolts and spacers between back of panel door and Plexiglass shield. Bolts and spacers shall be provided at shield corners and along shield edges as necessary to provide a rigid shield.

H. Terminals and Power Supplies

All terminals and power supplies shall be as manufactured by Phoenix Contact (no substitutes).

1. Provide terminal blocks for all incoming and outgoing control wires. Unless indicated otherwise on the Drawings, mount terminal blocks vertically. Wire and mount terminal blocks so that internal and external wiring do not cross over the terminals. No more than two conductors shall be terminated at each terminal connection.
2. Field wiring shall terminate on the "field side" of the terminal blocks. Do not connect internal panel wiring to the "field side" of the terminal blocks. Do not connect field wiring to the "panel side" of the terminal block.

3. Unless specified otherwise, all field wiring shall be connected to fused terminal blocks, including input and output terminals to and from PLCs. PLC loop powered analog signals shall be connected to two-level, non-fused terminal blocks.

4. Terminal blocks shall be modular, rail mounted, rated at 20 amperes, 600 volts capable of terminating wire sizes 12 through 24 AWG and constructed of polyamide thermoplastic. Terminal blocks shall be UL listed in accordance with UL 486A and 1059. All current carrying parts shall be made of copper or brass electroplated with tin/lead. Terminal connection shall be a screw clamp pressure plate connection, designed such that the clamping screw does not clamp the screw directly to the wire.

5. Provide symmetrical steel assembly rails, end brackets, jumper bars, and other accessories as required for a complete terminal block assembly.

6. Terminal blocks shall be consecutively numbered from top to bottom with preprinted marking tags. Tags shall be white polyamide and hot printed with black symbols so that the print is permanent.

7. Specific model terminal blocks shall be as follows:
   a. Phoenix Contact Terminal Block, Single-Level, Non-Fused, Model UK5N
   b. Phoenix Contact Terminal Block, Two-Level, Non-Fused, Model UKKB5
   c. Phoenix Contact Terminal Block, Fused, Model UKK5-HESILED
   d. Phoenix Contact End Cover, Model D-UKKB3/5
   e. Phoenix Contact Clamp, Model E/UK1.

Alternate model terminal blocks or terminal blocks from other manufacturers are not acceptable.

I. Power Supplies

Unless specified otherwise, power supply shall be Phoenix Contact Power Supply AC-DC 24V @ 2A 85-264V In, Enclosed DIN Rail Mount Mini Series, Model 2938730. Alternate model power supplies from other manufacturers are not acceptable.
2.06 MARKERS AND NAMEPLATES

A. Markers

Each signal, control, alarm, and indicating circuit conductor connected to a given electrical point shall be designated by a single unique number, which shall be shown on all manufacturer shop drawings. These numbers shall be marked on all conductors at every terminal. Conductor markers shall be pre-printed white identification tags with clear heat shrinkable tubing. Heat shrinking of the identification tags and clear tubing shall be in accordance with manufacturer's specifications.

1. Conductor identification tags shall be in accordance with the following requirements:
   a. The conductor identification tags shall consist of heat shrinkable flame retarded identification sleeves that fit tightly over the conductor or cable to be marked. Identification sleeves shall be made of a seamless cross-linked polyolefin with a 3 to 1 shrink ratio.
   b. The conductor identification tag system shall be UL recognized to Standard 224, MIL-M-81531. Identification tags shall be smear resistant prior to shrinking and achieve a permanent mark when shrunk, without the need for permatizing equipment. Identification marks shall be legible after 20 eraser rubs and 30 solvent brush strokes.
   c. Identification sleeves shall be seamless. Sleeves shall be resistant to common industrial fluids including Freon TF, Isopropyl Alcohol and Ethylene Glycol. Identification sleeves shall have a temperature range of \(-30^\circ C\) to \(105^\circ C\) and a dielectric strength of 500 V/mil minute. The identification sleeves shall be suitable for indoor or outdoor use. The conductor identification tag system shall be as manufactured by Raychem/Kroy Cable Marking, or Brady-Permasleeve White Polyolefin (B-342), or equal. Heat shrinkable thermoplastic tags are not acceptable.

2. The conductor identification sleeves shall be provided with heat shrink clear tubing in accordance with the following:
   a. To provide a long-term permanent marker in high ambient temperatures, a translucent (clear) shrink tube shall be placed over each wire marker (extending past both edges of adhesive wire marker) and heat shrunk.
b. The clear tube shall be suitable for high temperature performance, abrasion resistance and cut-through resistance and resistant to chemicals and solvents. The clear tubing shall meet the high temperature performance that meets or exceeds military industrial standards: MIL-1-23053, Test C, with UL VW-1 ratings. Operating temperature range shall be \(-55^\circ\text{C}\) to \(175^\circ\text{C}\). Product shall be Kynar as manufactured by Raychem, or equal.

B. Nameplates

1. Plainly and permanently identify control and power devices using the same identification as shown on the schematic diagrams. Show identification for devices inside the enclosure on a nameplate adjacent to, not on, the device.

   a. Exception No. 1: Where the size or location of the devices make individual identification impractical, such as on electronic assemblies, use group identification.

   b. Exception No. 2: Where panel layouts do not permit the mounting of identification nameplates adjacent to components, such as relays, place the permanent relay identification on the relay where it is plainly visible, and provide a second identification on the top of the panel wireway cover directly below the relay. Identify the wireway covers to show their proper location.

2. Identification nameplates for devices mounted inside and outside the control enclosure shall be one of the following:

   a. Laminated phenolic for engraving stock; a minimum of 0.062 inch thick with black background and white lettering. Fasten nameplates with stainless steel drive screws, or the equivalent. Use permanent adhesives for attaching nameplates to wireway covers.

   b. Stainless steel; a minimum of 0.031 inch thick for engraving stock or 0.012 inch thick for embossing stock. Fasten nameplates with stainless steel drive screws, or the equivalent.
2.07 WIRING METHODS

A. Panel wiring shall be neatly contained in panel wireways, including incoming and outgoing field control wiring. Provide separate wireways for internal wiring and field wiring. Panelways shall be colored white for 240 VAC circuits and colored light gray for 120 VAC, restricted slot design, with matching snap on overs. Provide panelways with mounting holes and nylon "push" rivets for mounting. Panelways material shall be PVC or noryl. Panelways shall be as manufactured by Panduit, or equal.

B. Provide minimum 2 inches of clearance between panelway and wire terminations to allow for clear viewing of wire identification marking.

C. Wiring run to control devices on the front door shall be tied together at short intervals and secured to the inside front door with Panduit adhesive mounts. Mounts shall be Clincher adjustable releasable clamp type for wire bundles 0.69 inch in diameter or smaller, or AM2-C mounts with Uni-Ty releasable nylon cable ties for bundles larger than 0.69 inch in diameter. Mounts shall be attached to front panel with Eastman 910 adhesive, or equal.

D. Signal and Control Circuit Wiring

1. Wire type and sizing:
   a. Conductor shall be flexible stranded copper machine tool wire.
   b. These shall be UL listed Type MTW flexible or Type SIS and shall be rated 600 volts.
   c. Wires for instrument signal circuits and alarm input circuits shall be No. 14 AWG, minimum.
   d. Wires connecting to PLC wiring arms shall be multiconductor No. 16 AWG, minimum.
   e. All other wires, including shielded cables, shall be No. 16 AWG, minimum. Shielded cables shall be used for analog signals.
   f. Wire insulation colors shall be as follows:
      i) Control Wiring
         a) PLC Inputs (Status) DI = Blue
         b) PLC Outputs DO = Brown
         c) 12VDC Positive = Red
d) 12VDC  Negative = Black  
e) 24VDC  Positive = Yellow  
f) 24VDC  Negative = Blue  
g) 120 VAC  Positive = Red  
h) 120 VAC  Negative = White  
i) 120VAC  Switch Leg = Do not use Black, Red or Blue  
j) 480 VAC  Switch Leg = Do not use Brown, Orange or Yellow  

ii) Power Wiring  

a) 480 VAC A-Phase = Brown, B-Phase = Orange, C-Phase = Yellow  
b) 120/208/240 VAC A-Phase = Black, B-Phase = Red, C-Phase = Blue  
c) Phase tape with colors is acceptable  
d) Foreign Power = Yellow  

Note: Match existing wiring when appropriate.

2.08 SPARE PARTS  

A. All spare parts shall be of the same material and workmanship, shall meet the same requirements, and shall be interchangeable with the corresponding original parts furnished. Spare parts shall be properly packaged for shipment and storage, and shall be labeled with the manufacturer's part number(s).

B. As a minimum, Contractor shall furnish the following spare parts:

1. Five (5) fuses of each type and size for single-phase power (including control power).

2. Two (2) indicating light assemblies for each type of pilot light.

3. One (1) control relay of each type and rating.

4. One (1) time delay relay of each type and rating.

C. Where control panels operate on 3 phase power and/or are equipped with motor starting equipment and components, Contractor shall furnish the following additional spare parts:

1. Three (3) fuses of each type and size for three-phase power.
2. Two (2) complete sets of 3-pole stationary and moving contact assemblies for each size AC contactor.

3. Two (2) operating coils for each size AC contactor.

4. One (1) contactor auxiliary contact of each type.

5. Three (3) contactor overload relays of each type and rating, each relay with a complete set of contact blocks.

6. One (1) spare set of heater elements for each heater rating provided.

PART 3 - EXECUTION

3.01 FACTORY TESTS

Prior to shipment, each control panel shall be inspected and tested for correct operation by the manufacturer. Each circuit shall be tested for continuity, short circuits, and fault grounds. The functional operation of the control panel shall be tested, including operation of all input and output (I/O) points, control devices, and motor controls. Temporary connections shall be provided between control panels and other system components. Subsequent testing of the system shall include, but not be limited to, programming of the PLC and operator interfaces. PLC system shall be programmed as required.

A. Initial Testing

Initial testing of the control panel shall include configuration of the PLC and its communications equipment (where PLC is provided) energizing each digital I/O and simulating each analog I/O using a loop simulator and calibrator. Circuits not energized shall be tested for continuity. Energized circuits shall be tested through all components from the terminal blocks in the control panel to the control devices and hardware I/O memory locations in the PLC. Testing of the control system shall be considered completed after control system operation has been successfully simulated at least four (4) times.

An I/O checklist shall be provided for all points in the control panel. The checklist shall include, for each point, the tag name of the point, a description of the point, comments, date and time of the test, and a signature line for the person performing the test. Where a PLC is provided, each digital point set and reset shall be shown. Verification of all analog points shall be shown at 0%, 25%, 50%, and 100% of range. The checklist shall be submitted to District.
B. **District-Witnessed Factory Testing**

District shall have the option of witnessing the functional shop test. Contractor shall notify District at least three (3) weeks prior to the scheduled functional shop test.

After completion of initial testing, the subsequent testing shall be conducted for inspection by District. All control functions and all status and alarm monitoring and indication shall be demonstrated under simulated operating conditions. Simulating equipment shall be provided and wired into the control system for this testing. The system shall be revised, modified, and adjusted as required by District during the testing period. Testing shall continue for the time period required by District to observe and verify any revisions and shall continue to District’s satisfaction. Where panel is equipped with a PLC, the PLC and HMI programs shall be loaded and fully tested in the factory. All hardware, instruments, and software shall be provided as necessary to perform the testing.

### 3.02 SITE TESTS

A. **General**

Control panel shall be tested with all field wiring connected. All adjustable set points and time delays shall be set as required. Operation of control panel and field devices shall be checked to verify correct operation. All required adjustments shall be made as required for correct operation.

B. **Specific Field Verifications**

The following specific field verifications shall be performed:

1. Panel control circuits are grounded with one (1) terminal of each load device connected to the grounded conductor.

2. Panel signal and control wiring are separated and installed in separate wireways with barriers between the power wiring and the signal and control wiring.

3. Panel is connected to the facility grounding system as specified.

4. Panel tops of wall-mounted panels are mounted at the same elevation (unless noted otherwise).

5. Panel inner door contains a copy of the as-built elementary and wiring diagrams.

6. Panel inner door contains copies of all applicable equipment warranties.
7. Panel inner door contains a drawing holder.

8. Panel as-built shop drawings and applicable equipment warranties are enclosed in a transparent, protective jacket.

9. All panel functions are as specified.

3.03 CONTROL PANEL MOUNTING

A. General

Control panels shall be field mounted as indicated on the Drawings or on equipment supplied as shown on District-accepted shop drawings.

B. Mounting Requirements

Unless indicated otherwise on the Drawings or in the specification sections for the packaged equipment systems, control panels shall be mounted as follows:

1. Control panels supported directly by concrete or concrete masonry walls shall be spaced apart not less than 1-5/8" by strut channel between panel and wall. Strut channel shall be attached to the wall as shown on the Drawings. Panels shall be attached to strut channel with stainless steel strut threaded studs, washers, and nuts. Unless specified others, strut stud diameter shall be 1/16” less than the panel mounting holes.

2. Panels shall be mounted to structures or support systems that are free of vibration or shock.

3. Support systems shall not be attached to handrails, process piping, or mechanical equipment, unless indicated on the Drawings.

4. Unless indicated otherwise on the Drawings, materials used for support of control panels shall be constructed of Type 316 stainless steel. Support systems, including panels, shall be designed to prevent deformation greater than 1/8" under the enclosed equipment load and an external load of 200 pounds in any direction.

5. Panels shall be shimmed to precise alignment so doors operate without binding.

6. Floor-mounted cabinets shall be mounted on 3" minimum high concrete housekeeping pads or grouted bases as indicated on the Drawings.
7. Terminals and terminal blocks shall be sprayed with a silicone resin, similar to Dow Corning R-4-3117 conformal coating, after all terminations and testing have been completed.

3.04 MANUFACTURER’S SERVICES

Unless specified otherwise, equipment manufacturer’s services shall be provided at the job site for the minimum number of 8-hour work days listed below, travel time excluded:

A. Two (2) work days to check the installation, calibrate the equipment, supervise start-up, and supervise testing of the system.

B. One (1) work day to instruct the District's personnel in the operation and maintenance of the equipment.

END OF SECTION
SPECIFICATIONS - DETAILED PROVISIONS
Section 17005 - General Instrumentation and Control Components

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PART 1 - GENERAL

1.01 DESCRIPTION

A. Contractor shall provide all equipment, materials, and labor, and required to place into service a fully configured, integrated, and operational instrumentation and control system as indicated on the Drawings and specified herein.

B. Design, fabricate, coordinate, install, calibrate, and test the instrumentation and control system to provide proper operation and to interface with related equipment and materials.

C. Furnish and install auxiliary and accessory devices necessary for system operation or performance and to interface with equipment specified herein and in other Sections of these Specifications.

1.02 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all Sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Division 11 – Equipment
2. Division 13 – Special Construction
3. Division 15 – Mechanical
4. Division 16 – Electrical
5. Division 17 – Instrumentation and Controls

1.03 REFERENCE STANDARDS AND CODES

A. International Society of Automation (ISA)

1. ISA S5.1 – Instrumentation Symbols and Identification.
2. ISA S5.3 – Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems.

3. ISA S5.4 – Instrument Loop Diagrams.

4. ISA S20 – Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.


B. National Electrical Manufacturers Association (NEMA)

C. National Fire Protection Agency (NFPA)

1. NFPA 70 - National Electrical Code (NEC).

2. NFPA 79 – Industrial Control Equipment.

Equipment and materials, including installation of same, shall meet or exceed the applicable requirements of the above standards and codes (latest edition).

1.04 INSTRUMENTATION AND CONTROL SUBCONTRACTOR

Contractor shall designate an Instrumentation and Control Subcontractor (ICS) to be responsible to furnish all services, equipment, and material specified herein.

A. Qualifications

1. As a minimum, the ICS shall have been regularly engaged in the design, selection, purchase, fabrication, installation, calibration, startup, and testing of instrumentation and control equipment on municipal water and wastewater projects.

2. ICS shall have been regularly engaged in performing coordination, design, and selection of equipment and controls to interface between instrumentation and control equipment, and to interface with system control panels, motor control centers, variable frequency drives, packaged systems, programmable logic controllers, etc. for municipal water and wastewater projects of similar or larger magnitude for at least 5 years.

3. Contractor shall submit ICS qualifications and project references (5 minimum) for District review and approval.
4. Personnel employed for system engineering, coordination, supervision, installation, startup, operational testing, and training shall be regularly employed and trained by the ICS.

B. Responsibilities

1. Design, select, fabricate, coordinate, calibrate, and test the instrumentation and control system to provide proper operation and to interface with related equipment and materials furnished by other suppliers under other Sections of these Specifications, with existing facilities (where required), and with District provided Remote Telemetry Unit (RTU) equipment and/or Supervisory Control and Data Acquisition (SCADA) system equipment.

2. Coordinate the design, selection, and fabrication of instrumentation and control systems furnished by others, and confirm that the proposed equipment will provide the required monitoring/control and shall properly interface with other equipment systems (new and existing).

3. Design and prepare control and interconnect diagrams (loop drawings) for all field devices, local control panels, main control panels, motor control centers, etc. showing wiring interconnections for all project equipment, instrumentation, and controls (including existing equipment, instrumentation, and controls).

4. Review and approve shop drawings prepared by the motor control center, variable frequency drive, and other electrical equipment suppliers. ICS shall date and sign said shop drawings prior to submittal to the District for review.

5. Coordinate work so that all components of the instrumentation system, including primary measuring, indicating, transmitting, receiving, recording, totalizing, controlling, alarming devices, and all appurtenances are selected, designed, and calibrated to provide the specified accuracy and performance, and are completely compatible and shall function as specified.
6. Provide auxiliary and accessory devices necessary for system operation or performance and to interface with equipment provided by other suppliers under other Sections of these Specifications, with existing facilities (where required), and District provided RTU equipment and/or SCADA system equipment. These devices include, but are not limited to, current isolators, signal conditioners, transducers, and interposing relays. These devices shall be provided regardless of whether they are shown on the Drawings or not, and shall be at no additional cost to the District.

7. Installation of instrumentation and control equipment and materials need not be performed by the ICS; however, the ICS shall provide onsite technical supervision of the installation.

8. Prior to installation of any conduit associated with instrumentation and controls, the ICS shall verify conduit size and conduit runs with the Electrical Subcontractor and equipment suppliers for specific equipment to be furnished, and notify the District of any conflicts or deviations.

9. Coordinate services of manufacturer's engineering representatives for instrumentation and control equipment during installation, startup, operation, and instruction of District personnel.

Contactor shall subcontract the work specified herein to a qualified ICS. All work performed is the responsibility of the Contractor even though references are made herein to work requirements and responsibilities of the ICS and Electrical Subcontractor.

1.05 PERFORMANCE SPECIFICATIONS AND DRAWINGS

Instrumentation and control systems shall be furnished and installed to provide equipment performance, operation control, and/or monitoring functions as specified on the Drawings, in specific equipment sections of these Specifications, or in the Special Conditions. Control schematic diagrams, where provided on the Drawings, show control wiring and control functions for specific equipment. ICS shall prepare, or coordinate preparation of all wiring and control diagrams, and computer programs. ICS shall furnish and install all instrumentation and control components required to provide said specified performance and operation.

1.06 INSTRUMENTATION AND CONTROL EQUIPMENT

Instrumentation and control equipment shall be as specified herein, per individual equipment sections of these Specifications, and as shown on the Drawings. Not all products specified herein are necessarily required for this project.
1.07 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A. Shop Drawings

Contractor shall prepare and submit complete and organized information, drawings, and technical data for all equipment and components. All drawings shall be legible and reduced to a maximum size of 11” x 17” for inclusion within the submittal. Shop drawings shall include, but not be limited to, the following:

1. Detailed Bill of Materials for all instrumentation and control equipment, and appurtenances, listing: manufacturer's name, quantity, description, size, range, and catalog/part number.

2. Summary data sheets for all instrumentation and control equipment in accordance with ISA-20.00.01 format. As a minimum, data sheets shall include the following information: Plant equipment name/number and ISA tag number shown on the Drawings (where provided); item name as specified herein, or separate Specification sections, or indicated on the Drawings; manufacturer’s complete model number, item location; input/output characteristics; range, size, and gradation in engineering units; materials of construction for wetted parts and enclosure; and enclosure NEMA classification.

3. Complete documentation for all instrumentation and control equipment, including: manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, illustrations, and data in sufficient detail to demonstrate compliance with Specification requirements. Manufacturer’s literature and data shall be marked to clearly delineate all applicable information and crossing out all inapplicable information.

4. Engineering selection and design parameters and calculations for instrumentation and control components including range, material compatibility for process medium, temperature ratings for project ambient conditions, temperature error and proposed mitigation for same, and other pertinent selection and sizing criteria.

5. Manufacturer’s data and drawings showing dimensions, physical configurations, methods of connecting instruments and control equipment together, installation and mounting details, single instrument loop diagrams, and wiring schematics.
6. Product data sheets for instrument cables and controller/transmitter cables. Installation requirements for cables and conductors, including shielding, splicing, and grounding requirements.

7. Control program for programmable controllers (if applicable) with complete listing and description of all program functions, all input and output parameters, and factory settings.

8. Interface between instruments, controllers, motor starters, control panels, variable frequency drives, PLCs, etc., District furnished equipment (when supplied), and other equipment related to the instrumentation and control system.

9. Control ladder diagrams for all control, protection and monitoring circuits, including control panel wiring. Ladder diagrams shall show all switches, push buttons, relays, timers, etc. Show all interconnections between power sources and device elements of a particular system or equipment, and all interlocks with other equipment/systems in a manner that fully indicates the circuit function and operation.

10. Loop diagrams for each monitoring and/or control loop. The loop diagrams shall show all components of the loop: analog, digital, and discrete including all relays, switches, signal isolators, etc. which are being provided for proper operation. Loop diagrams shall be provided for all analog and control system components, including those components specified in other Sections of these Specifications and/or shown on the Drawings. Loop diagrams shall be prepared according to ISA-S5.4 format, and shall also include the following:

   a. All interconnecting wiring between equipment, panels, terminal junction boxes, and field mounted components. Show all panel terminal board identification numbers and all wire numbers. Show all intermediate terminations between field elements and panels.

   b. The location of all devices.

   c. The instrument description, including type, manufacturer, model number, range, set points, and operation (e.g. fail open, open on energization, normally closed, etc.) as applicable.

   d. The instrument loop power requirements back to the termination on the terminal block, fuse block (including fuse size), etc., as applicable.
e. All grounding points within cabinets and panels and identify the connection point of individual components.

f. Each diagram shall include a table summary with output capability of the transmitting instrument, input impedance of each receiving instrument, estimate of loop wiring impedance based on wire size and approximate length, total loop impedance, and reserve output capacity.

11. Interconnection diagrams for all field devices, local control panels, main control panels, motor control centers, etc. showing wiring interconnections for all project equipment, instrumentation, and controls (including existing equipment, instrumentation, and controls). Interconnection diagrams shall be provided for all equipment and appurtenances, including equipment specified in other Sections of these Specifications and/or shown on the Drawings. Interconnection diagrams shall be point-to-point type and shall show all conduit and wiring interconnections with electric panel and circuit numbers for all power sources.

12. Proposed nameplate descriptions for all instrumentation and control equipment.

B. Field Testing and Demonstration Plan

Contractor shall prepare and submit for approval a written plan for field testing and demonstrating that each instrumentation and control system meets the specified operational and performance requirements. Submit a written plan with step by step procedures to be used during pre-startup, startup, and final demonstration testing of system operation and performance.

C. Operation and Maintenance Manual

Contractor shall submit a detailed Operation and Maintenance (O&M) Manual for all instrumentation and control equipment specified herein and incorporated into the Work. The O&M Manual shall be provided in accordance with the requirements of the District's General Conditions, Section 01430, and as specified herein.
The O&M Manual shall include, but not be limited to, the following:

1. Equipment Performance Data and Drawings
   a. Detailed Bill of Materials for all instrumentation and control equipment, and appurtenances, listing: manufacturer's name, quantity, description, size, range, and model/part number.
   b. Manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, and illustrations.
   c. Manufacturer’s data and drawings showing dimensions, physical configurations, installation and mounting details, single instrument loop diagrams, and wiring schematics.
   d. Control diagrams, loop diagrams, and interconnect diagrams for all field devices, local control panels, main control panels, motor control centers, etc. for all project equipment, instrumentation, and controls (including existing equipment, instrumentation, and controls).

2. Equipment Installation Requirements
   a. Complete, detailed installation instructions for all instrumentation and control equipment, and appurtenances.

3. Equipment Operation Data
   a. Complete and detailed instructions for adjusting all equipment settings, including: input power, output signal, range, span, sensitivity, etc.
   b. Complete and detailed user manuals and operating instructions, including operator interface menus, programming, and setup parameters for all controllers.
   c. Printed list of all final setup parameters for each controller, including factory settings and any field modifications to factory settings.
4. **Equipment Service and Maintenance Data**

   a. Maintenance data shall include all information and instructions required by District's personnel to keep equipment adjusted and calibrated so that it functions properly under the full range of operating conditions.

   b. Explanation with illustrations as necessary for each maintenance task.

   c. Recommended schedule of maintenance tasks.

   d. Troubleshooting instructions.

   e. List of maintenance tools and equipment.

   f. Recommended spare parts list.

   g. Names, addresses and phone numbers of all manufacturers and manufacturer's local service representatives.

5. **Manufacturer Warranties**

   D. **Final O&M Manual**

   Upon successful completion of startup and initial operation, Contractor shall submit a Final O&M Manual in accordance with the requirements of the District’s General Conditions, Specification Section 01430, and as specified herein.

   1. As-built drawings (including all field changes) for all wiring and interconnection diagrams shall be incorporated into the Final O&M Manuals.

   2. In addition, pre-startup and post-startup written certification reports as specified herein shall be included in the Final O&M Manual.
1.08 QUALITY ASSURANCE

A. Manufacturers

To facilitate the District’s future operation and maintenance, furnish equipment which is the product of one manufacturer to the maximum extent possible. Where this is not practical, all equipment of a given type shall be the product of one manufacturer.

All equipment shall be of the manufacturer’s latest design and shall produce or be activated by signals which are standards for the water and wastewater industry.

B. Model Numbers

Model numbers supplied herein are provided for information purposes only, to assist Contractor in selecting equipment that conforms to the Specification and Drawing requirements. In case of any conflict between model numbers provided and the descriptive requirements specified herein, the descriptive requirements shall govern.

C. Standard of Quality

Only equipment of the types and sizes specified which has been demonstrated to operate successfully shall be furnished. All material and equipment furnished shall be listed by and shall bear the label of Underwriters Laboratories (UL), Edison Testing Labs (ETL), or Factory Mutual (FM).

D. Instrumentation and Control Subcontractor’s Certifications

Prior to startup and initial operation of all instrumentation and control equipment (including existing instrumentation and control equipment), the ICS shall submit a written report stating that equipment has been coordinated, calibrated, properly installed, and is ready for startup. After startup and when equipment is ready to be operated, the ICS shall submit a written report for the instrumentation and control equipment certifying that the equipment is ready to be operated, is safe to operate and has been checked, inspected, calibrated, and adjusted as necessary; has been operated under varying service conditions and operated satisfactorily; and is fully covered under the terms of the guarantee.
PART 2 - PRODUCTS

2.01 GENERAL

A. Where indicated on the Drawings, specified by the individual equipment sections in these Specifications, or by the Special Conditions, the instrumentation and control components shall be as specified herein.

B. Unless specified otherwise, all equipment shall be suitable for operation over an ambient temperature range of 15°F to 122°F, and at a maximum elevation of 3,300'. Cooling or heating equipment shall be provided if required by the instrumentation and control equipment. Where dissipation of heat cannot be adequately accomplished with natural convection (NEMA 4X enclosures) or forced air ventilation (NEMA 1 gasketed enclosures), additional cooling or heating shall be furnished.

C. Unless specified otherwise, electrical enclosures for indoor equipment shall be rated NEMA 1 gasketed, or better. Unless specified otherwise, electrical enclosures for outdoor equipment shall be rated NEMA 4X. Outdoor enclosures with sunlight exposure shall be provided with sun shields. In addition, instrumentation located in areas subject to wash down or exposure to chemicals shall be provided with NEMA 4X electrical enclosures.

D. All instrumentation in hazardous areas shall be intrinsically safe and shall be approved for use in the particular hazardous (classified) location in which it is to be installed.

E. All panel mounted instruments shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be of one manufacturer.

F. Analog measurements and control signals shall be as indicated herein, and shall vary in direct linear proportion to the measured variable, except as noted. Unless specified otherwise, analog output signals shall be 4 to 20 milliamperes (ma) DC.

G. Unless specified otherwise, power for the instrument and control equipment shall be 120VAC, single phase, 60 Hz.

H. Where DC power supplies are not furnished integral with any one instrument system loop, Contractor shall provide a separate solid-state power supply and fuses (primary and secondary).
2.02 GENERAL REQUIREMENTS FOR COMPONENTS AND APPURtenANCES

A. Materials and Components

Electrical materials and components shall be as specified in Section 16050, as indicated on the Drawings, and as specified herein.

B. Signal Isolators, Converters, and Power Supplies

Signal isolators shall be furnished and installed in each measurement and control loop, wherever required to ensure adjacent component impedance match, or where feedback paths may be generated. Signal converters shall be included where required to resolve any signal level incompatibilities. Signal power supplies shall be included, as required by the manufacturer's instrument load characteristics, to ensure sufficient power to each loop component.

C. Tags and Nameplates

1. Each field instrument shall be provided with a rectangular Type 316 stainless steel tag. The tag shall be engraved with the project instrument tag number. The instrument tag shall be attached directly to the instrument with stainless steel screws or with a stainless steel chain.

2. Each panel mounted instrument, controller, or control component shall be provided with a nameplate. The nameplate shall be engraved with the project description of the device. Nameplates shall conform to the requirements of Section 16050.

D. Wiring and Cables

1. Wire Type and Sizes

All power and control wiring shall be provided in accordance with Section 16050. Instrument supply power conductors shall be minimum #12 AWG. Control signal conductors shall be minimum #14 AWG. Wire insulation colors shall be in accordance with Section 16050.
2. Cables

Shielded cables shall be minimum #16 AWG and shall be in accordance with Section 16050. Instrument transducers or sensors requiring special cable shall be provided by the instrument manufacturer and shall be factory connected to the device. Cable between the transducer or sensor and corresponding controller shall be provided with the device. ICS shall verify the length of cable required for each specific installation location. Cable shall be installed in a single run with no splices.

3. Wire Termination

Conductors from field instruments or components shall terminate in control panels, MCC sections, etc. at terminal blocks.

4. Wire Marking

All conductors and cables shall be marked at termination points with a marking system as specified in Section 16050.

2.03 FLOAT SWITCHES AND INTRINSICALLY SAFE RELAYS

A. Float switches shall be designed for operation in water and raw sewage and shall be hermetically sealed in high impact corrosion resistant polypropylene or polyurethane. Cable shall be minimum 16 gauge multi-strand polyvinylchloride (PVC) jacketed cable (oil and water resistant) suitable for underwater use and heavy flexing service. Float switches shall be rated minimum 4 A at 120 VAC. Each float switch shall be utilized for one operation. A single float switch shall not be used as example for pump start and stop.

B. Float switches shall be as manufactured by Flygt Corporation, Warrick Controls, Anchor Scientific Inc., Consolidated Electric Co., or equal.

C. Unless specified otherwise, each float switch shall be provided with an intrinsically safe relay complete with reduced voltage transformer and contacts. Intrinsically safe relays shall be specified for use in NEC, Class I, Division 1 (hazardous) locations, and shall be Factory Mutual or UL listed for explosion proof service. Intrinsically safe relays shall be as manufactured by Warrick (no substitutes).
2.04 PRESSURE GAUGES

A. Unless otherwise shown or specified, pressure gauges shall be weatherproof and provided with 4-1/2" dials, 1/4" or 1/2" threaded connections, and black phenolic resin, black Pocan, or epoxy coated aluminum cases with safety glass windows. Gauge socket and internal component materials shall be compatible with the process medium. As a minimum, gauge sockets and internal components (including bourdon tubes and tips, bellows, or diaphragms) shall be constructed of Type 316L stainless steel. Gauges shall be suitable for dry or liquid filled operation. Gauge accuracy shall be ±0.5% of span per ASTM B40.1, Grade 2A. Gauge range shall be selected for 150% of the working pressure or vacuum of the monitored medium. Gauge dials shall be provided with white backgrounds and black markings. Gauge units shall be applicable to the medium and pressure and/or vacuum range.

B. Pressure gauges shall be as manufactured by Ashcroft, Wika, Marsh Instruments, or equal.

2.05 DIAPHRAGM SEALS

A. General

Where shown on the Drawings or specified elsewhere, diaphragm seals shall be provided between the process medium and the pressure or vacuum sensing element (e.g. gauge, transmitter, or switch). Diaphragm seals shall be provided with upper and lower housings and diaphragms that are welded or clamped between the housings. Upper and lower housings shall be connected with bolts (4 minimum). Diaphragm seals shall be provided with 1/2" threaded female NPT process connections, 1/4" or 1/2" threaded instrument connections, and lower housings with 1/4" flushing connections. Unless otherwise shown on the Drawings, one (1) diaphragm seal shall be provided for each instrument for direct mounting.

Manufacturer shall be responsible for selecting the diaphragm seal based on each specific instrument assembly, including the diaphragm size, diaphragm material, diaphragm spring constant, assembly fill fluid medium, assembly fill fluid volume, and connection piping size (if not direct mounted) to maintain a minimum accuracy of ± 1% of full instrument range based on an ambient temperature range of 20°F to 120°F and exposure to direct sunlight. In addition, manufacturer shall be responsible for selecting diaphragm, bottom housing, and
gasket materials to be compatible with the process medium. As a minimum, diaphragm, lower housing, upper housing, and bolts shall be constructed of Type 316L stainless steel.

Diaphragm seals shall be as manufactured by Ashcroft, Wika, or equal.

B. **Water Service (Potable and Non-Potable)**

Diaphragms seals for water service shall be of all Type 316L stainless steel construction, including diaphragm, lower housing, upper housing, and hardware.

C. **Chlorine Service (Solution)**

Diaphragms seals for chlorine service shall be of all Hastelloy C-276 construction, including diaphragm, lower housing, upper housing, and hardware.

### 2.06 PRESSURE SWITCHES

A. Pressure switches shall utilize bourdon tubes, diaphragms, or bellows as the sensing/actuating element. Unless otherwise specified, the sensing/actuating element material shall be Type 316 stainless steel. The set point shall be readily field adjustable over the range specified. Switches shall have deadband adjustable up to a maximum of 100% of switch range. Pressure range shall be as indicated on the Drawings. Switches shall be SPDT, rated for 5 A at 240 VAC. Unless specified otherwise, switch enclosures shall be rated NEMA 4X. Switch pressure connection shall be 1/4” FNPT.

B. Pressure switches shall be Model 836 as manufactured by Allen Bradley (no substitutes).

### 2.07 DIFFERENTIAL PRESSURE SWITCHES

A. Differential pressure switches shall utilize bourdon tubes, diaphragms, or bellows as the sensing/actuating element. Unless otherwise specified, the sensing/actuating element material shall be stainless steel. The set point shall be readily field adjustable over the range specified. Switches shall have deadband adjustable up to a minimum of 50% of switch range. Repeatability shall be ±1% of range. Switch pressure range shall be as indicated on the Drawings. Switches shall be SPDT, rated for 10 A (minimum) at 240 VAC. Unless specified otherwise, switch enclosures shall be rated NEMA 4X. Switch pressure connections shall be 1/4” FNPT.

B. Differential pressure switches shall be as manufactured by Winters, Ashcroft, or equal.
2.08 PRESSURE TRANSMITTERS

A. Pressure transmitters shall be electronic two wire devices with the following features: adjustable span, zero and damping adjustments, integral indicator scaled in engineering units, solid state circuitry and 4-20 mA output. Accuracy shall be ±0.25% of span. Overrange capacity, without affecting calibration, shall not be less than 150% of maximum range. Process wetted materials shall be compatible with the process fluid, unless specified for installation with a diaphragm seal. Unless specified otherwise, process wetted materials shall be Type 316 stainless steel. Body material shall be Type 316 stainless steel. Transmitter process connection shall be 1/2" NPT. Fill fluid, unless otherwise specified, shall be silicone oil. Transmitter housing shall be epoxy coated low copper aluminum alloy and rated NEMA 4X, unless specified otherwise.

B. Unless specified for direct mounting, pressure transmitters shall be provided with mounting brackets and installation kits. Bracket shall be suitable for surface mounting, pipe mounting, or block and bleed valve manifold mounting. Mounting bracket wetted materials shall be compatible with the process fluid, unless specified for installation with a diaphragm seal. Unless specified otherwise, mounting bracket wetted materials shall be constructed of Type 316 stainless steel. Mounting brackets, installation kits, and accessories shall be provided by the pressure transmitter manufacturer.

C. Pressure transmitters shall be as manufactured by Foxboro (no substitutes).

2.09 DIFFERENTIAL PRESSURE TRANSMITTERS

A. Differential pressure transmitters shall be electronic two wire devices with the following features: adjustable span, zero and damping adjustments, integral indicator scaled in engineering units, solid state circuitry and 4-20 mA output. Accuracy shall be ±0.25% of span. Over-range capacity, without affecting calibration, shall not be less than 150% of maximum range. Span shall be field adjustable over at least a 4 to 1 range. Process wetted materials shall be Type 316 stainless steel. Body material shall be Type 316 stainless steel. Process connections shall be 1/2" NPT. Fill fluid, unless otherwise specified, shall be silicone oil. Transmitter housing shall be epoxy coated low copper aluminum alloy and rated NEMA 4X, unless specified otherwise. A three (3) valve manifold shall be provided with the transmitter, unless indicated otherwise on the Drawings. Manifold wetted materials shall be Type 316 stainless steel.
B. Differential pressure transmitters shall be provided with mounting brackets and installation kits. Bracket shall be suitable for surface mounting, pipe mounting, or block and bleed valve manifold mounting. Mounting bracket wetted materials shall be shall be compatible with the process fluid, unless specified for installation with a diaphragm seal. Unless specified otherwise, mounting bracket wetted materials shall be constructed of Type 316 stainless steel. Mounting brackets, installation kits, and accessories shall be provided by the differential pressure transmitter manufacturer.

C. Pressure transmitters shall be as manufactured by Foxboro (no substitutes).

### 2.10 ULTRASONIC LIQUID LEVEL MEASUREMENT SYSTEM

#### A. General

Ultrasonic liquid level measurement systems shall consist of a microprocessor based electronic controller, a non-contacting transducer, and cable from transducer to controller. The electronic controller shall be capable of receiving, processing, and transmitting ultrasonic signals. All operating parameters shall be entered via the controller keypad. For liquid level, the controller shall, upon demand, display current head, temperature, and distance from transducer to liquid level.

The ultrasonic liquid level measurement system shall be Miltronics Multi Ranger Plus as manufactured by Siemens (no substitutes).

#### B. Service

The transducer shall be capable of submergence without degradation. Transducer shall function over an ambient temperature range of -40°F to 200°F, and shall be rated by FM and CSA for Class I and II hazardous environments. Controller shall function over an ambient temperature range of 15°F to 122°F.

#### C. Performance

The transducer shall transmit and receive an acoustic signal to accurately measure liquid level over a range of 0' to 30', unless specified otherwise. Point of zero reference shall be operator adjustable. The output signal shall be proportional to level from 0 to 100% with a resolution of ±0.1%. The transducer shall be provided with integral temperature sensor for speed-of-sound compensation. Unless specified otherwise, the transducer shall be the Echomax XPS Series with a 6° beam angle.
D. Level Measurement Features

1. Controller shall be provided with output indicating meter with four character LCD display programmable in engineering units of: feet, inches, or percent of span.

2. Interconnecting Cable: Cable between transducer and controller shall be supplied with unit, and shall be suitable for a maximum system length of 1,000'. Contractor shall verify length of cable required for each specific installation. Cable shall be installed in a single run with no splices.

3. Discrete Outputs: Controller shall provide up to five discrete outputs, each adjustable over entire scale range.

4. Alarms: Alarms shall be programmable for level, rate of change of level, differential level, or loss of echo.

5. Alarm Messages: Loss of echo and cable circuit open or shorted.

E. Controller Interface

1. Controller Output: 4-20 mA DC output, current isolated, into a maximum of 600 ohms (return to ground).

2. Power Supply: Unit shall operate on 120-Volt, 60 Hz power, unless specified otherwise.

3. Discrete Outputs: Form "C" SPDT relays, 5 amps (continuous), non-inductive, 250 VAC.

4. Controller shall be provided with necessary output functions and communication interfaces to enable implementation of control and monitoring operations as specified in other equipment sections of these Specifications, and/or shown on the Drawings.

F. Controller Enclosure

1. Controller enclosure shall be rated NEMA 4.

2. Indoor controllers shall be wall mounted or panel mounted. Where controller is specified to be panel mounted, it shall be flush mounted in the panel door. ICS shall provide all brackets, supports, bezels, etc. necessary for flush panel mounting.
3. Outdoor controllers shall be provided with stainless steel, sheet metal sun shields (20 gauge, minimum). Sun shields shall be open at the front and bottom, and shall be of sufficient size to allow access to controller for operation and maintenance. Free edges shall be rolled. Sun shields shall be constructed without sharp edges and corners.

2.11 SUBMERSIBLE LIQUID LEVEL MEASUREMENT SYSTEM

A. General

The submersible liquid level measurement system shall continuously monitor the liquid level in a groundwater well, tank, or wet well. The measurement system shall be of the submersible level pressure type. As a minimum, the measurement system shall consist of a submersible pressure sensor, cable, and accessories, as specified herein. Unless indicated otherwise on the Drawings, the system power supply and display unit shall be the RTU or MCP identified to receive the analog level signal. The power supply shall be 24 VDC normal (9 to 28 VDC operation range).

The submersible liquid level measurement system shall be Model PTX 1830 as manufactured by Druck, Inc. (GE Sensing).

B. Sensor and Cable

1. The sensor shall be an all-titanium device that accurately measures depth or level in a well, tank, or body of fluid. A micro-machined silicon measuring element shall be sealed within a titanium pressure module assembly and shall be fully isolated from the pressure media. The pressure module assembly shall be contained in a slimline, welded titanium body and terminated with an injection molded cable assembly.

2. The molded cable shall be a two-conductor cable with aluminum-mylar shield, Kevlar strain cord, nylon vent tube, and polyurethane jacket. The integral cable vent tube shall reference the sensor to atmospheric pressure. The molded polyurethane cable along with the internal potting in the sensor transmitter shall be constructed to prevent the ingress of water into the cable and back of the sensor transmitter for indefinite immersion in a pressure of 1,000 psi.

3. The cable jacket material shall be impervious to water and chemicals normally found in groundwater, surface water, and wastewater.
4. Cable lengths shall be available in 1 ft. increments up to a maximum of 1,600 ft. ICS shall determine the required cable length for each specific installation location.

5. The sensor transmitter shall be a 4-20 mA, two-wire, loop powered device. The sensor accuracy shall be ±0.1% of full scale. Long term stability shall be ±0.1% of full scale per year. The sensor shall be suitable for operating temperatures ranging from -4 to 140°F, and sensor output shall be temperature compensated from 30 to 86°F.

6. The sensor operating pressure range shall be as indicated on the Drawings, or specified in the Special Conditions. The sensor shall be capable of being over-pressurized to 400% of the operating full scale pressure (to a maximum of 2,000 psig) with negligible effect on calibration.

7. The sensor shall be rated by FM for use in NEC Class I, Division 1, Groups A through D hazardous environments.

C. Accessories

Unless specified otherwise, each submersible liquid level measurement system shall be provided with the following accessories:

1. A sensor termination enclosure with the following components:
   a. DIN rail mounted terminal blocks for termination of sensor cable conductors and conductors from 4-20 ma shielded cable to signal termination point.
   b. Gore-Tex micro-filter designed to prevent the ingress of water into the enclosure.
   c. Desiccant module with sight gage for determining desiccant change intervals.
   d. PVC base and clear polycarbonate cover. Enclosure shall be rated NEMA 4X.
   e. 2-inch pipe mounting kit.

2. A cable clamp designed to hold cable by distributing the clamping force over an 8-inch long section of cable jacket.
3. A sensor slimline sink weight.

4. A direct calibration adaptor.

5. Spare desiccant modules (5 total) in sealed containers.

D. Lightning Surge Arrestor

Where Drawings show installation of a submersible sensor in a surface water location, the sensor shall be provided with an integral lightning surge arrestor assembly certified to IEC Standard 61000-4-5 (Level 4). Contractor shall provide a separate ground rod assembly for the surge arrester. The resistance of the ground rod assembly shall be less than 100 ohms. A minimum #12 AWG ground conductor shall be provided from the lightning arrester to the ground rod and shall interconnect with the drain-wire on the sensor cable.

E. Intrinsically Safe Barriers

Where Drawings show installation of a submersible sensor in a wastewater location classified as hazardous by the NEC, the sensor shall be provided with the appropriate intrinsically safe barriers.

2.12 Conductance Liquid Level Measurement System

A. General

Each conductance liquid level measurement system shall consist of level sensors, connection fitting, and relays as shown on the Drawings and specified herein. Contractor shall furnish and install all material and appurtenances as necessary to provide a complete liquid level measurement system.

Conductance liquid level measurement system shall be as manufactured by Warrick Controls Inc., Gems Sensors Inc., or equal.

B. Level Sensors

Level sensors shall be conductance type, utilizing electrodes and the conductivity of the process fluid itself to measure level. The system shall be equipped with multiple level sensing electrodes and one ground electrode. The number and lengths of level sensing electrodes shall be as shown on the Drawings. Unless specified otherwise, the electrodes shall be constructed of Type 316 stainless steel and shall be provided with PVC heat shrink sheathings.
C. **Connection Fitting**

Each connection fitting shall be pressure-tight, and suitable for connection to the flanged top outlet of a pressure vessel. Connection fitting shall be provided with an integral epoxy coated aluminum terminal housing and Type 316 stainless steel electrode couplings. The number of electrode couplings shall accommodate the number of level-sensing electrodes shown on the Drawings and required grounding electrode. Connection fitting flange shall be rated for a pressure that is equal to or greater than the pressure vessel rating. As a minimum, the connection fitting flange shall be rated for a working pressure of 230 psig at 100°F. The connection fitting flange shall be constructed of Type 316 stainless steel or 1018 carbon steel. Contractor shall coordinate the size of the pressure vessel top outlet flange with the connection fitting flange provided by the level measurement system manufacturer.

D. **Relays**

Liquid level measurement system relays shall be solid-state, plug-in modules suitable for 11-pin octal sockets. Relays shall be general purpose, single level or differential service, with DPDT dry contacts rated for 5A (minimum) at 120 VAC. Relays shall be suitable for operation on 120 VAC primary voltage with 12 VAC secondary voltage.

### 2.13 CONDUCTIVITY MEASUREMENT SYSTEM

A. **General**

The conductivity measurement system shall continuously measure conductivity in aqueous solutions. The measurement system shall be sense, transmit and display/control liquid conductance, expressed in microSiemens/centimeter (mS/cm). Conductivity measurement system shall include: sensor, sensor mounting assembly, controller, junction box, interconnecting cables, cable plugs, and all appurtenances necessary to provide a complete and operable measurement system. Sensor material and mounting assembly material shall be compatible with measured liquid. The ICS shall confirm material compatibility with the measured liquid and shall confirm the pressure and temperature ratings of all components with the maximum operating conditions.

Conductivity measurement system shall be the Hach 3700-SC Electrodeless Conductivity System as manufactured by Hach Company (no substitutes).
B. **Conductivity Sensor**

Conductivity sensor shall be inductive electrodeless type. The conductivity sensor shall have a built-in Pt 1000 RTD temperature compensator. The sensor shall be water resistant. Sensor wetted materials shall be available in polypropylene, PVDF, PEEK, or PFA Teflon. Unless specified otherwise, sensor wetted materials shall be PFA Teflon. The sensor shall be rated for a maximum pressure of 200 psi and a maximum temperature of 200°C. The sensor shall be equipped with an integral 5 conductor cable. Unless specified otherwise, the cable shall be provided with a Teflon coated jacket rated for 200°C.

C. **Sensor Mounting Assembly**

Sensor shall be convertible style with 3/4-inch NPT end connection suitable for immersion mounting, union mounting, or insertion mounting, as indicated on the Drawings and as specified below:

1. Immersion mounting – sensor shall be directly fastened on the end of a CPVC pipe (1/2-inch diameter by 4-foot long) with 1/2 x 3/4-inch NPT coupling and plastic pipe-mount junction box with terminal strip.

2. Union mounting – sensor shall be fastened to a union adapter for mounting into a standard 2-inch NPT pipe tee. Unless specified otherwise, union and pipe tee shall be construction of Type 316 stainless steel and shall be rated for a maximum pressure of 200 psi and a maximum temperature of 60°C.

3. Insertion mounting – sensor shall be fastened into a 2-inch ball valve assembly for mounting into a standard 2-inch NPT pipe tee. Unless specified otherwise, ball valve assembly and pipe tee shall be construction of Type 316 stainless steel and shall be rated for a maximum pressure of 80 psi and a maximum temperature of 95°C.

Mounting assembly hardware shall be provided by the sensor manufacturer.

D. **Controller**

1. The conductivity controller shall be a programmable microprocessor based electronic device with full input/output signal isolation. The controller shall be correctly matched to the conductivity sensor. Unless specified otherwise, controller shall be configured to operate two (2) digital sensor inputs.

2. Controller display shall be graphic dot matrix LCD with LED backlighting.
The controller shall be provided with the following features: two (2) conductivity analog output signals (4-20 mA) capable of transmission into a maximum impedance of 500 ohms; four (4) user configurable SPDT relays (Form C) rated 5A to 230 VAC and 30 VDC resistive maximum; and 25W sensor/network card with Modbus RS232/RS485 network connection.

Conductivity measurement range shall be 0.5 to 10,000 mS/cm, 0 to 99.99 % concentration, and 0 to 9999 ppm total dissolved solids. Repeatability shall be ±2% of full span. Operating temperature range shall be -20 to 60°C.

Unless specified otherwise, power supply to controller shall be 120 VAC, 60 Hz.

Controller enclosure shall be rated NEMA 4X, and shall be suitable for panel or surface mounting as indicated on the Drawings.

Unless specified otherwise, controller shall be Hach SC200 Model LXV404.99.00552 as manufactured by Hach Company (no substitutes).

E. Accessories

Each conductivity measurement system shall be provided with all accessories and components necessary for a complete and operational system. As a minimum, each conductivity measurement system shall be provided with the following accessories:

1. Digital gateway designed to provide a digital interface between the conductivity sensor and controller. Unless specified otherwise, each digital gateway shall be provided with a mounting clip, NEMA 4X FRP junction box with back panel (sized for housing digital gateway), and cord fittings for sensor cable and digital extension cable.

2. Digital extension cable with end connectors for connection to digital gateway and controller. The ICS shall determine the required cable length for each specific installation location.

A digital termination box shall be provided when the distance between the digital gateway and controller exceeds 100 meters.
2.14 ANCILLARY MATERIALS AND COMPONENTS

A. Pipe and Fittings

Unless indicated otherwise on the Drawings, all pressure gauges, pressure switches, and pressure transmitters shall be connected to process piping with Class 150 threaded fittings, Schedule 40 pipe nipples, and isolation ball valve. Unless specified otherwise, all fittings, pipe nipples, and ball valves shall be constructed of Type 316 stainless steel.

B. Block and Bleed Valve Manifolds

Where indicated on the Drawings, pressure transmitters and differential pressure transmitters shall be provided with block and bleed valve manifolds capable of isolating process sensing lines, venting to atmosphere, and connection of test equipment for instrument calibration. Block and bleed valve manifolds shall be 3-valve or 5-valve, as indicated on the Drawings. All wetted materials shall be compatible with the process fluid. Unless specified otherwise, valves shall be constructed of Type 316 stainless steel. Block and bleed valve manifolds shall be as manufactured by Foxboro, Anderson Greenwood, or equal.

Unless indicated otherwise on the Drawings, block and bleed valve manifolds shall be provided with mounting kits for mounting the manifold and pressure transmitter assembly to a 2” diameter Schedule 40 hot dipped galvanized pipe stanchion.

C. Protective Coatings

All metallic enclosures, except stainless steel, shall be provided with a corrosion resistant factory coating, fusion bonded epoxy or equivalent coating system.

D. Fasteners

Unless indicated otherwise on the Drawings, equipment and appurtenances shall be securely mounted to walls and floors using Type 316 stainless steel wedge anchors or epoxy anchors for masonry and concrete structures, and Type 316 stainless steel machine bolts and lag screws for metal and wood structures (respectively).
PART 3 - EXECUTION

3.01 GENERAL

A. It is the general intent of these Specifications that installation of all instrumentation and control equipment; and supply and installation of all field wiring, conduit, and wiring external to the motor control centers, control panels and electrical equipment shall be performed by the Electrical Subcontractor. The ICS shall furnish all instrumentation and control equipment specified herein and supervise installation by the Electrical Subcontractor. In addition, the ICS shall coordinate design of controls within motor control center(s), control panels and electrical equipment, and ensure compatibility of design with equipment and equipment systems.

B. The ICS's attention is directed to the electrical and mechanical details of this project. Referral to these portions of the Contract Documents shall be required in order to understand the full intent and scope of work required.

3.02 INSTALLATION

A. General

1. All instrumentation and control equipment shall be installed in accordance with the manufacturer's written instructions, NEC standards, requirements and standards specified herein, and as shown on the Drawings.

2. Wiring between process instruments and remote mounted signal converters/controllers shall conform to the manufacturer’s recommended cable type and procedures.

3. All instrumentation and control equipment shall be grounded per manufacturer's requirements. Contractor shall coordinate grounding between process instruments and remote mounted signal converters/controllers, and electrical ground system to ensure compliance with the manufacturer's recommended grounding procedures.

4. Minimum process connection size for pressure gauges, switches, and transmitters shall be 1/2" NPT. Provide threaded reducers and 1/4" diameter nipples to transition from 1/2" diameter process connection appurtenances to 1/4" device pressure connections.
5. Unless indicated otherwise on the Drawings, all pressure gauges, pressure switches, and pressure transmitters shall be connected to process piping with Class 150 threaded fittings, Schedule 40 pipe nipples, and isolation ball valve. Unless specified otherwise, all fittings, pipe nipples, and ball valves shall be constructed of Type 316 stainless steel.

B. Pressure Gauges

1. Pressure gauges shall be liquid filled (fill fluid as selected by manufacturer), except where diaphragm seals are specified.

2. For diaphragm seal installations with lower housing constructed of materials other than Type 316 stainless steel, all pipe fittings, pipe nipples, and isolation ball valves shall be constructed of the same material as the diaphragm seal lower housing.

C. Pressure Switches

1. Pressure switches shall be provided with Type 316 stainless steel pulsation dampeners, except where diaphragm seals are specified.

2. For diaphragm seal installations with lower housing constructed of materials other than Type 316 stainless steel, all pipe fittings, pipe nipples, and isolation ball valves shall be constructed of the same material as the diaphragm seal lower housing.

D. Pressure Transmitters

1. Direct connected pressure transmitters shall be provided with Type 316 stainless steel pulsation dampeners, except where diaphragm seals or block and bleed valve manifolds are specified.

2. For diaphragm seal installations with lower housing constructed of materials other than Type 316 stainless steel, all pipe fittings, pipe nipples, and isolation ball valves shall be constructed of the same material as the diaphragm seal lower housing.

3. Bracket mounted pressure transmitters and bracket mounted pressure transmitters with block and bleed valve manifolds shall be mounted to 2” diameter Schedule 40 hot dipped galvanized pipe stanchions with stainless steel U-bolts. Each stanchion shall be provided with 3/8” thick steel base plate and four 3/8” diameter anchor bolts for floor mounting.
E. **Differential Pressure Transmitters**

1. Where indicated on the Drawings, differential pressure transmitters shall be provided with block and bleed valve manifolds. Block and bleed valve manifolds shall be in furnished accordance with the requirements specified herein.

2. For diaphragm seal installations with lower housing constructed of materials other than Type 316 stainless steel, all pipe fittings, pipe nipples, and appurtenances shall be constructed of the same material as the diaphragm seal lower housing.

3. Unless indicated otherwise on the Drawings, differential pressure transmitter brackets or manifolds shall be mounted to 2” diameter Schedule 40 hot dipped galvanized pipe stanchions with stainless steel U-bolts. Each stanchion shall be provided with 3/8” thick steel base plate and four 3/8” diameter anchor bolts for floor mounting.

4. Connections from process piping to differential pressure transmitter brackets or block and bleed valve manifolds shall be Schedule 40 piping as specified herein, or Type 316 stainless steel tubing (0.035” wall thickness) with compression (Swagelok) fittings.

F. **Float Switches**

1. Unless indicated otherwise on the Drawings, float switches shall be provided with stainless steel clamps and appurtenances suitable for mounting switches to a vertical 3/4-inch pipe.

2. Vertical pipe shall be accessible by District personnel without entering the structure and shall be capable of being easily removed for float cleaning and adjustment.

### 3.03 FIELD QUALITY CONTROL

A. **Manufacturer's Engineering Representative**

The services of manufacturer's engineering representative especially trained and experienced in the installation of the equipment shall be provided to supervise the installation, be present when the instruments and equipment are first put into operation, and inspect, check, adjust as necessary, and calibrate the instruments. All costs for representative's services shall be included in the Contract Price.
B. Calibration

1. Unless specified otherwise, each field instrument shall be calibrated after installation, in conformance with the requirements specified herein and the instrument manufacturer's instructions. Those components having adjustable features shall be set for the specific conditions and applications of the project, and shall be within the specified limits of accuracy.

2. Each field instrument shall be calibrated at 0%, 25%, 50%, 75%, and 100% of span using test instruments to simulate inputs and read outputs that are rated to an accuracy of at least 5 times greater than the specified accuracy of the instrument being calibrated. Test instruments shall have accuracies traceable to the National Institute of Standards and Technology (NIST).

3. A calibration sheet shall be prepared for each instrument recording all calibration readings, including the readings as finally adjusted within the specified tolerances. Contractor shall submit a written report to the District on each instrument. The report shall include the field calibration sheet for each instrument, and associated manufacturer’s standard calibration sheet (if applicable).

4. Elements and equipment which cannot achieve proper calibration or accuracy, either individually or within a system, shall be replaced.

C. Certify Proper Installation

After all installation and connection work has been completed, the ICS and manufacturer’s representative shall check it all for correctness, verifying polarity of electric power and signal connections, making sure all process connections are free of leaks, and all other similar details. The ICS and manufacturer's representative shall certify in writing that for each loop or system checked out, that equipment is properly installed, setup, calibrated, and is ready for operation. Refer to Part 1.08C herein for ICS Certification.
3.04 FIELD TESTING

A. Operational Demonstration Testing

Contractor shall demonstrate that the performance of installed instrumentation and control equipment and materials complies with specified requirements. Equipment shall be operated through its full range for not less than 2 hours unless a longer period is specified elsewhere. Immediately correct defects and malfunctions with approved methods and materials in each case, and repeat the demonstration. Operational demonstration testing shall conform to the approved startup, initial operation and demonstration testing plan.

B. Field Operation Tests

Unless specified otherwise, test all instrumentation and control systems for not less than 24 hours, with no interruptions except for normal maintenance. Field operation tests shall conform to the approved test plan.

1. Testing Materials and Equipment

Contractor shall furnish all labor, equipment, and materials for required tests, including all test instruments, recorders, gauges, chemicals, power, etc.

2. Testing Methods

Contractor shall perform field tests on equipment as specified in the Special Conditions and/or Detailed Provisions for the specific equipment. Unless specified otherwise, operate systems continuously for a minimum of 24 hours. Cause equipment to cycle through the applicable range of operation at a steady rate of change. Induce simulated alarm and distressed operating conditions, and test controls and protective devices for correct operation in adjusting system functions or causing system shutdown.

3. Defects

Contractor shall immediately correct all defects and malfunctions disclosed by tests. Contractor shall use new parts and materials as required to perform corrective work, as approved by the District. The specified total test period shall be extended by the interruption time for corrective work.
4. Test Records

Contractor shall continuously record all function and operation parameters during the entire test period. Contractor shall submit complete, well organized, and clearly labeled test data to the District for review and approval.

3.05 INSTRUCTION

District's personnel shall be instructed in the functions and operation of each system and shall be shown the various adjustable and set point features which may require re-adjustment, resetting or checking, re-calibration, or maintenance by them from time to time. Instruction shall include interactions of the systems, operations, shutdowns, alarms, failure, and controls. This instruction shall be scheduled at a time arranged with the District at least two (2) weeks in advance. Instruction shall be classroom type for a minimum of four (4) hours, or as specified by the Special Conditions. Instruction shall be given by the ICS and other qualified persons who have been made familiar in advance with the systems in this Facility.

END OF SECTION 17005
SPECIFICATIONS - DETAILED PROVISIONS
Section 17010 - Programmable Logic Controller

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SECTION 17010
PROGRAMMABLE LOGIC CONTROLLER

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section specifies the requirements for a programmable logic controller (PLC) provided to monitor and control process conditions for an equipment system, including packaged equipment systems. The PLC shall be supplied by the Instrumentation and Control Subcontractor (ICS) or the manufacturer of the packaged equipment system. The requirements of the individual equipment system are equally applicable to the work specified herein. Where conflict exists, the individual equipment system sections shall take precedence.

B. The equipment system PLC shall interface with the Plant and/or District Supervisory Control and Data Acquisition (SCADA) system, and shall include all components required for a complete, fully functional and operable process monitoring and control system.

C. The PLC shall include all required enclosures, chassis, power supplies, central processing units, input/output (I/O) systems, communication systems, interfaces, instruments, devices, wiring, and terminations, as specified herein and as shown on the Drawings.

D. PLC components specified herein shall be provided, as well as any ancillary or incidental equipment or devices, whether identified or not, that are required to support the monitoring and control of the equipment system and permit full use of the process equipment’s capabilities.

1.02 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Sections of the Specifications specifying equipment systems controlled by PLCs.
1.03 REFERENCE STANDARDS AND CODES

All materials and equipment specified herein, including installation of same, shall conform to or exceed the applicable requirements of the following standards and codes (latest edition) to the extent that the provisions thereof are not in conflict with other provisions of these Specifications.

A. International Society of Automation (ISA)
   1. ISA S5.1 – Instrumentation Symbols and Identification
   2. ISA S5.3 – Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems
   3. ISA S5.4 – Instrument Loop Diagrams

B. National Electrical Manufacturers Association (NEMA)
   1. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
   2. NEMA ICS 6 – Industrial Control and Systems: Enclosures

C. National Fire Protection Agency (NFPA)
   1. NFPA 70 - National Electrical Code (NEC)
   2. NFPA 79 – Electrical Standard for Industrial Machinery

D. Underwriters Laboratories (UL)
   1. UL 508A – Standard for Industrial Control Panels
   2. UL 698A – Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations

1.04 DEFINITIONS

The following definitions are used throughout this Section:

A. AI: Analog Input
B. AO: Analog Output
C. CPU: Central Processing Unit
D. DI: Digital Input
E. DO: Digital Output
F. EEPROM: Electrically erasable programmable read-only memory
G. HMI: Human-Machine Interface
H. I/O: Input and/or Output
I. LAN: Local Area Network
J. Peer to Peer: Communication between two or more devices, typically PLCs, in which each device can control the data exchange.
K. PID: Control action, proportional plus integral plus derivative.
L. PLC: Programmable Logic Controller
M. RAM: Random Access Memory
N. Remote I/O: Any and all I/O that is located remotely from the processor.
O. SCADA: Supervisory Control and Data Acquisition
P. TCP/IP: Transmission Control Protocol and Internet Protocol
Q. UPS: Uninterruptible Power Supply

1.05 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.
A. **Shop Drawings**

Contractor shall prepare and submit complete and organized information, technical data, and drawings for all equipment and components. All drawings shall be legible and reduced to a maximum size of 11” x 17” for inclusion within the submittal. Shop drawings shall include, but not be limited to, the following:

1. Detailed Bill of Materials for all PLC panel hardware, and associated materials and components, listing: manufacturer's name, quantity, description, size, and catalog/part number.

2. Complete documentation for all PLC panel hardware and associated components (i.e. PLC chassis backplane, CPU, power supply, I/O modules, communication modules, HMI, UPS, enclosure, relays, terminal blocks, etc.), including: manufacturer's product literature, specifications, performance capabilities, features and accessories, dimensions and weights, illustrations, and data in sufficient detail to demonstrate compliance with Specification requirements. Manufacturer's literature and data shall be marked to clearly delineate all applicable information and crossing out all inapplicable information.

3. PLC block diagram showing all PLC components, HMI, and all communication interfaces, including Ethernet and serial communications to all equipment, devices, and SCADA.

4. PLC control logic documentation in hard copy format, including a logic diagram and a control strategy in written, well organized sections using easy to understand narrative text explaining all input and output parameters, and all monitoring, control, and alarming functions. Provide a list of all addresses referenced in the logic diagram with a description of data associated with each address.

5. Complete PLC I/O lists with I/O description, tags, addresses, and field terminal numbers.

6. Where applicable, provide addressing for all communication network nodes using an Ethernet network connection. Coordinate Ethernet TCP/IP addressing with the District.

7. Hard copy documentation for HMI screens, including color prints of all proposed screen displays, written descriptions for each screen display parameter and input function.
8. PLC panel hardware arrangement drawings (plan view, and interior and exterior elevation views) with all hardware and components clearly shown, dimensioned, and labeled. Drawings shall show the equipment assembly, space requirements, clearances, and locations for conduits and anchor bolts.

9. Nameplate data including the nameplate material, heights of letter and inscriptions.

10. Control ladder diagrams for all hard wired control, protection, and monitoring circuits. Ladder diagrams shall show all switches, lights, pushbuttons, relays, etc., and shall be labeled with all associated wiring and termination numbers.

11. PLC panel wiring schematics. Wiring schematics shall show all interconnections between power sources, PLC, HMI, and all panel devices and components, and shall show all wiring numbers and termination numbers.

12. Loop diagrams for each monitoring and/or control loop. The loop diagrams shall show all components of the loop: analog and discrete I/O with reference to each PLC module I/O point, field instruments and components, and local switches, relays, signal isolators, etc., which are being provided for proper monitoring, control and operation. Loop diagrams shall be provided for all PLC I/O and all control system components, including those components specified in other Sections of these Specifications and/or shown on the Drawings. Loop diagrams shall be prepared according to ISA-S5.4 format, and shall also include the following:

   a. All interconnecting wiring between equipment, field instruments and devices, local control panels (if applicable), and PLC panel. Show all panel terminal block identification numbers and all wire numbers. Show all intermediate terminations between field elements and panels.

   b. The location of all equipment, instruments, and devices.

   c. The instrument/device description, including type, manufacturer, model number, range, set points, and operation (e.g. fail open, open on energization, normally closed, etc.) as applicable.

   d. The instrument/device loop power requirements back to the termination on the terminal block, fuse block (including fuse size), etc., as applicable.
e. All grounding points within panels and cabinets, and identify the connection point of individual components.

f. Each diagram with an instrument shall include a summary table with output capability of each transmitting instrument, input impedance of each receiving instrument, estimate of loop wiring impedance based on wire size and approximate length, total loop impedance, and reserve output capacity.

13. Spare parts list as specified in this Section.

14. Test procedures for factory testing and field testing required by Section 16950.

B. Operation and Maintenance Manual

Contractor shall submit a detailed Operation and Maintenance (O&M) Manual for all PLC equipment and components specified herein. The O&M Manual shall be provided in accordance with the requirements of the District's General Conditions, Specification Section 01430, and as specified herein.

The O&M Manual shall include, but not be limited to, the following:

1. PLC Performance Data and Drawings
   a. Detailed Bill of Materials for all PLC equipment and components, listing: manufacturer's name, quantity, description, size, range, and model/part number.
   b. Manufacturer's product literature, specifications, performance capabilities, features and accessories, and illustrations.
   c. Manufacturer’s data and drawings showing dimensions, physical configurations, installation and mounting details, and wiring schematics.
   d. Control ladder diagrams for all hard wired control, protection, and monitoring circuits. PLC panel wiring schematics. Loop diagrams for each monitoring and/or control loop.

2. PLC Installation and Operation Requirements
   a. Complete, detailed installation and operation instructions for all PLC equipment and components.
3. PLC Programming Software and Licenses
   a. Complete and detailed user manuals for all PLC and HMI programming software packages.
   b. Software licenses issued to the District for all programming software packages. Software licenses originally assigned to others and transferred to the District will not be acceptable. Unless specified otherwise, two (2) complete licenses shall be provided for programming software packages for use on general purpose laptop computers with Windows 10 (or latest) operating systems.
   c. A hardcopy printout and Flash Drive of all PLC and HMI programming and configuration files.

4. PLC Service and Maintenance Data
   a. Service and maintenance data shall include all information and instructions required by District's personnel to keep the PLC and all associated components functioning properly under the full range of operating conditions.
   b. Explanation with illustrations as necessary for each service and maintenance task.
   c. Recommended schedule of service and maintenance tasks.
   d. Troubleshooting instructions.
   e. List of maintenance tools and equipment.
   f. Recommended spare parts list.
   g. Names, addresses and phone numbers of all manufacturers and manufacturer's local service representatives.

5. Manufacturer Warranties
C. Final O&M Manual

Upon successful completion of startup and initial operation, Contractor shall submit a Final O&M Manual in accordance with the requirements of the District’s General Conditions, Specification Section 01430, and as specified herein. In addition to the O&M Manual requirements specified above, the Final O&M Manual shall be supplemented with the following:

1. As-built drawings (including all field changes) for all wiring and loop diagrams shall be incorporated into the Final O&M Manuals.

2. A hardcopy printout and Flash Drive of all final PLC and HMI programming and configuration files (including all field changes).

1.06 DESIGN REQUIREMENTS

A. Environmental

The PLC, including all associated components, shall be of industrial grade capable of operating continuously and satisfactorily in harsh environments. The PLC shall meet or exceed the following environmental requirements:

1. Operating temperature: 0 to 55°C (+32 to +131°F)

2. Storage temperature: -25 to 70°C (-13 to 158°F)

3. Relative humidity: 30 to 95% non-condensing

4. Altitude: 0 to 6,500 feet

5. Degree of protection: NEMA 4X

6. Shock resistance: 147m/s² for 11ms

7. Vibration resistance shall be in compliance with IEC 60068 and 61131.

The complete PLC shall be guaranteed to operate satisfactorily within the specified NEMA rated enclosure in ambient temperatures ranging from +32 to +110°F.
B. General Functions

As a minimum, the PLC system shall be designed to perform the following functions:

1. Provide fully automated control of equipment system operation, including monitoring process conditions, providing control feedback, optimizing process performance, and interfacing with other Plant PLCs and/or the District SCADA system, as shown on the Drawings and as specified in individual equipment system sections and herein.

2. Where specified, provide manual override of the automated controls via the HMI. Unless specified otherwise, critical system monitoring, alarm, and safety shutdown functions shall remain in effect.

3. Unless specified otherwise, hold all system alarms locally until manually reset from the PLC HMI or from the SCADA system.

4. Communicate with the SCADA system, which shall provide supervisory control of the equipment system operation via an Ethernet communication link.

5. Provide control capabilities to restart the equipment system, including associated equipment, as required after a Plant shutdown or power failure in coordination with and as commanded by the SCADA system.

C. General Performance Capabilities and Features

As a minimum, the PLC system shall be provided with the following performance capabilities and features:

1. The PLC shall be capable of handling analog inputs/outputs (4-20ma); and discrete inputs/outputs (contact closures, pulses; momentary or latch operation) in addition to power monitoring.

2. Input/output modules shall be furnished to accommodate all process monitoring and control specified in the equipment system specifications and shown on the Drawings plus any additional modules not shown, but essential to controlling and monitoring the system, providing a complete and final product.
3. All control programs shall reside in the PLC. All monitoring and control functions specified in the equipment system specifications and control loops/logic diagrams shown on the Drawings, and any additional controls necessary for operation of the system, shall be supplied and implemented by the equipment system manufacturer.

4. The PLC shall incorporate pre-programmed self-diagnostic software routines for maintenance.

5. The PLC shall incorporate a watchdog function to monitor: internal CPU failure, CPU memory failure, loss of communication between CPU and I/O modules, and CPU failure to execute logic program.

6. Unless specified otherwise, activation of alarms and stopping of equipment shall result from de-energization of control circuits, rather than energization of control circuits.

7. Unless specified otherwise, PLC failure mode shall be designed such that the loss of PLC supply power or output control signals to the equipment shall result in the equipment shutting down or operating in a predetermined safe mode.

8. PLC logic system failure shall not preclude proper operator intervention.

9. Unless specified otherwise, safety shutdown of equipment or equipment system shall require manual operator intervention via PLC HMI prior to reestablishing operation of the equipment or system.

10. Internal PLC system status and faults shall be monitored and displayed on the HMI. As a minimum, monitored items shall include:
   a. Power-up diagnostic (self-test) - passed/failed.
   b. Memory - OK/loss of memory.
   c. CPU - OK/fault
   d. Program run status – OK/fault
   e. Scan time - OK/overrun.
   f. Battery status – OK/low

   As a minimum, each monitored item shall be displayed on the HMI on a single PLC system status screen.
11. PLC and HMI programming and configuration shall incorporate the following
general strategies and functions:

a. All calculations, analog value trip points, timers, etc. shall be
accomplished in the PLC and not in the HMI.

b. All analog inputs to the PLC shall be configured in the HMI software
for historical trending.

c. All set points for minimum and maximum values of analog outputs
shall be operator adjustable via the HMI software.

d. All set points for minimum and maximum values of analog inputs for
process monitoring/control shall be operator adjustable via the HMI
software.

e. All open/close automatic valves and remote start/stop motors
controlled by the PLC system shall have an adjustable maximum time
value allowed to either open/close or start/stop. Failure to achieve
the control function within this maximum time value shall result in a
time out alarm for each piece of equipment. An alarm shall be
generated from the PLC to the HMI for indication of the control
function time out failure (e.g. Pump XXX Fail to Start, Valve XXX Fail to
Open).

f. The status of all alarms shall be latched until manually acknowledged
via the HMI.

g. HMI entries by the operator, such as set points and operation modes,
shall be displayed on the process screens for information.

12. Prevent unauthorized access to PLC and HMI programs and configurations
with password-based security in the PLC and HMI software.

13. The PLC system shall be designed with high noise immunity to prevent
occurrence of false logic signals resulting from switching transients, relay and
circuit breaker noise, or conducted and radiated radio frequency
interference. Incorporate noise suppression and inductive load suppression
design into PLC input, output, and logic modules.

14. At a minimum, the PLC system shall be capable of using Ethernet/IP,
Modbus, and OPC as communication protocols to communicate with other
PLCs on the network and Plant SCADA or District SCADA, as applicable.
15. All PLC components such as PLC power supply, I/O modules, CPU, communication modules, backplane, wiring harnesses, etc. shall be provided with conformal coatings for protection against moisture and chemical contaminants.

16. All PLC component connections shall be screw-in type. Plug-in type connections will not be acceptable. All terminal blocks shall be screw-in type and shall provide a location for identifying associated terminal numbers.

17. Independent line fuses or circuit breakers shall be provided, per the manufacturer’s recommendation, for each power supply, input module, output module, and other modules with separately derived power requirements.

18. All communication signals and 4-20 mA signals shall be properly conditioned for the PLC and protected from all sources of radiated energy or harmonics.

D. Appurtenances

1. The PLC processor, I/O modules, power supplies, and communication modules shall be provided as a complete system, as specified in the equipment system specification section and herein, and as shown on the Drawings. The PLC shall include all necessary components and hardware for a complete and fully functional system.

2. All special chassis or panel mounted power supplies, special interconnecting and programming cables, special grounding hardware, or isolation devices shall be furnished as required for proper operation of the equipment.

3. Signal converters, signal boosters, amplifiers, special power supplies, intrinsically safe relays and current repeaters, surge suppression devices, and isolation devices shall be furnished and installed as required for proper operation of the equipment.

E. Fabrication, Installation, and Testing

1. In addition to the design, fabrication, delivery, installation, and testing requirements specified herein, the PLC panel shall comply with all applicable requirements in Section 16950 - Custom Control Panels.

2. Equipment and components shall be Underwriters Laboratory (UL) listed for the purpose or UL recognized.
3. The assembled PLC panel and individual components shall be UL listed and labeled. The assembled panel shall have a factory applied UL 508A label.

4. Where applicable, intrinsic safety barriers within the PLC panel shall be provided per UL 698A with factory applied labels as required by UL.

5. The PLC system shall be factory tested prior to delivery per Specification Section 16950.

1.07 INSTALLED-SPARE REQUIREMENTS

A. Each PLC shall be provided with the following spare capacities.

1. I/O points – 20 percent spare I/O capacity for each type of I/O signal required. All spare I/O shall be wired to the field terminal blocks.

2. PLC chassis and backplane – the greater of:
   a. 20 percent spare capacity, or
   b. 3 spare backplane slots.

   All spare backplane slots shall be equipped with slot filler modules.

3. PLC memory – 50 percent spare program volatile memory capacity after all required programming is in place and operating. Executive or “housekeeping” programs shall not be counted in memory size rating.

4. Field terminal blocks – 10 percent spare terminal blocks for each type of I/O signal required. These spare terminal blocks shall be in addition to the wired terminal blocks required for spare I/O capacity.

1.08 SPARE PARTS

A. Each PLC shall be provided with the following spare parts. Spare parts shall be packaged for long term storage and identified with labels describing contents.

1. I/O Modules: provide a spare of each type of module installed.

2. CPU: provide a spare for each type of CPU installed.

3. PLC Power Supplies: provide a spare for each type of power supply installed.
4. Memory Cards: provide a spare for each type of memory card installed.

5. Communication Module: provide a spare for each type of communication module installed.

B. Provide manufacturer’s recommended special tools for the PLC and associated components. Special tools shall include, but not be limited to: module installation/removal tools, terminal block installation/removal tools, reset tools, and drivers for special fasteners and screws.

1.09 MANUFACTURER SERVICES AND COORDINATION

A. The ICS or packaged equipment system manufacturer shall design, engineer, fabricate, program, factory test, and deliver to the project site a complete and fully functional PLC to provide process monitoring and control of the specified equipment system and to interface with the Plant and/or District SCADA system.

B. The manufacturer shall coordinate with the Contractor, Electrical Subcontractor, Instrumentation and Control Subcontractor, and District to ensure proper communication between PLC, Plant equipment, instrumentation and control devices, and SCADA system(s).

C. The ICS or packaged equipment manufacturer shall provide qualified and experienced engineering representatives to participate in project software development and coordination workshops with the District. As a minimum, the manufacturer’s representatives shall attend two (2) separate workshop sessions (one half day per session). The workshop sessions shall address the following:

1. PLC I/O list. Conventions for tag names and addressing.

2. PLC program monitoring and control strategy. PLC local/remote and auto/manual control modes.

3. PLC communication and control approach (PLC to PLC, and SCADA to PLC).

4. Network address assignments, where applicable.

5. Alarm acknowledgment and reset strategy.

6. Communication monitoring between PLCs and SCADA.

7. Software security approach.
8. Strategy for automatic restart following a power failure (Plant and equipment system).

9. HMI screens (standard objects, data display, and color conventions).

D. The manufacturer shall provide programming services incorporating direction received during the workshops with the District, including a complete monitoring and control logic program for operation of the equipment system. In addition, the manufacturer shall provide programming services for fully configured HMI screens.

E. After the equipment system has been installed, the manufacturer shall perform pre-startup, startup, commissioning, and field testing of the system.

F. Upon completion of system startup and testing, the manufacturer shall provide the District with a certificate of proper installation, and provide onsite training to District personnel.

1.10 QUALITY ASSURANCE

A. The District believes that the manufacturers listed herein are capable of producing equipment and/or products that will satisfy the requirements of these Specifications. The listing of specific manufacturers herein does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed herein are not relieved from meeting these Specifications in their entirety; and, if necessary, they shall provide non-standard, custom equipment and/or products. Contractor shall be responsible for confirming that the proposed equipment and/or products will meet these Specifications.

B. Products of one manufacturer and of the same series or family of models shall be used to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer support services.

PART 2 - PRODUCTS AND MATERIALS

2.01 PLC CAPABILITIES AND PERFORMANCE

A. General

1. The PLC shall collect data, perform process control functions, communicate with other PLCs, and distribute process information along the local area network.
2. The PLC shall be capable of providing proportional, integral, and derivative control in real time, with preemptive priority multitasking.

3. The PLC shall be able to have its program downloaded from a remote workstation over the local area network, and be locally programmed from a portable laptop computer.

4. The executive firmware of all intelligent modules shall be stored in flash memory and shall be able to be updated in the field using standard programming tools. Executive firmware files shall be readily available via the PLC manufacturer’s website.

5. The PLC shall be field expandable to allow for the expansion of the system by the simple addition of hardware and configuration of same.

6. A controller, or I/O module, shall be capable of being inserted under power, without upsetting the process being controlled by other controllers.

7. The PLC shall have the capability to preselect the failure status of each output point in the event of CPU failure.

2.02 PLC SOFTWARE REQUIREMENTS

A. Programming Software

As a minimum, the PLC programming software shall have the following capabilities:

1. Allow the use of all textural and graphic languages specified in IEC 61131-3, including:

   a. Relay Ladder Diagram (LD)

   b. Function Block Diagram (FBD)

   c. Structured Text (ST)

   d. Sequential Function Chart (SFC)

The processor shall be able to program in all four languages in one processor. Standard Boolean logic for coils, timers/counters, etc., shall only be limited by the amount of memory in the processor.
2. Data Manipulation:
   a. All memory locations shall be tag based with the ability to add and delete online without taking the processor offline. In addition the tags shall have the ability to be named to reflect usage based on user conventions. The tags shall also have the ability to be aliased to other tag names if required.
   b. Compare, move, block move, copy, and PID.
   c. Table read/write/sort/compare/search/average.

3. Math:
   a. Add, subtract, multiply, and divide.
   b. Square root, exponentiation, and logarithms (base ten and natural).
   c. Floating point number accuracy of four places.
   d. Engineering unit scaling function block for analog values.

4. Documentation:
   a. Address descriptions four lines by seven characters with edit, copy, and delete capability.
   b. Rung descriptions with edit, copy, and delete capability.
   c. Cut and paste logic capability.
   d. Ability to import/export all documentation to/from standard text files.

5. PID Blocks: support both dependent and independent equations.

6. Support user defined data structures with mixed numeric types.

7. Ability to store and retrieve instruction comments, program comments, rung comments, and other comments and notes in the PLC processor.

8. Communications: support peer to peer message read and write.
9. The PLC programming software shall have the following tools for monitoring and troubleshooting the PLC program.
   
a. A breakpoint capability to automatically halt the program just before a certain sequence is initiated.

b. Ability to advance the program step by step to insure proper operation.

c. Ability to create watch points for desired variables. These watch points shall display the real time value of the variable.

d. Ability to create a table that will track a chosen variety of variables.

10. The PLC shall be programmed using a single programming software package. The programming software package shall have integrated tools for PLC programming, network configuration, and communication capabilities. PLC’s that use separate programming, communication, and network configuration software will not be accepted. The programming software shall run on general purpose personal computers with Windows 10 (or latest) operating systems.

B. Editor

1. The PLC programming software package shall include an IEC 61131-3 compliant editor.

2. The logic editor shall support the creation of routines in all of the following four programming languages: LD, FBD, ST, and SFC.

3. The editor and operating system shall support the import or export of specific, user-selected portions of logic, into and out of both a running controller as well as an offline controller configuration file. When performing this function online, the controller shall have a “test edit” function, such that the programmer can disqualify, or cancel the edit before fully accepting the changes.

C. Security

The PLC system shall have capability to password protect access to the PLC. The system shall ensure security by authenticating users against a set of defined user accounts and access privileges.
2.03 PLC HARDWARE

A. General

The PLC shall be an integrated, modular, chassis type system designed for mounting the CPU (processor) module, I/O modules, communication modules, and power supply unit. The PLC shall be Allen Bradley 1756 ControlLogix or 1769 CompactLogix System (no substitutes).

B. Processor (CPU)

1. The PLC system shall execute logic in a single processor module. The processor shall be capable of executing all monitoring and control functions required by the Specifications and Drawings.

2. The processor shall have the ability to run multiple tasks with the ability to run each task at a particular scan rate that may be updated while running with the ability to prioritize each task.

3. Processor Features:

   a. Unless specified otherwise, the processor shall have a minimum of 4 MB of base program and data memory. Specified memory capacity shall be available entirely for storing the operational control program. Specified spare capacity and executive or “housekeeping” programs shall not be counted in memory size rating.

   b. A non-volatile memory card (EEPROM or Flash Memory) shall store the entire user program and configuration, and shall be capable of reloading the program into RAM if a fault in the program is detected or if the program is lost due to loss of battery power or other means. Unless specified otherwise, the non-volatile memory card shall have a minimum of 8 MB of memory.

   c. As a minimum, the processor shall be provided with one built-in USB port. The required 10BASE-T/100BASE-TX RJ45 Ethernet/IP ports shall be provided as built-in ports and/or via separate communication modules.

   d. The processor will be capable of being programmed with a general purpose laptop computer.
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e. The PLC shall use a lithium battery to back up the PLC RAM. A BAT light shall indicate when it is time to replace the battery.

f. The PLC shall have status lights to indicate various functions, including run, processor fault, I/O fault, and communication activity.

C. I/O Modules

1. General Requirements

PLC I/O modules shall be provided as required to accept signals as indicated on the Drawings, as specified in Specifications for equipment, and as specified herein. I/O modules shall be provided to accept all active signals and all specified spares. PLC I/O modules, including installation in the PLC enclosure shall conform to the following:

a. All I/O modules shall be enclosed in a plastic housing. I/O modules shall be plugged into a modular type I/O rack with common backplane. All cables required to connect to all other PLC system components shall be provided.

b. I/O modules shall be capable of being removed and inserted into the I/O rack under power without affecting any other I/O modules in the rack.

c. I/O of a particular type (digital inputs, digital outputs, analog inputs, and analog outputs) shall be grouped together.

d. All I/O wiring shall be to removable terminal blocks that permit removal and replacement of a module without disturbing the wiring or any other I/O module. Removable terminal blocks shall be suitable for accepting #14 AWG I/O wiring.

e. Identify on I/O modules and associated terminal blocks, the specific I/O points as they have been addressed in the PLC system.

f. All field wiring shall be terminated on terminal blocks within the PLC enclosure. The field terminal blocks shall be sized to accommodate all active I/O points and required spares. Field terminals shall be provided for the individual termination of each analog signal shield. The PLC shall be factory prewired between the field terminal blocks and I/O module removable terminal blocks.
g. Unless specified otherwise, provide interposing relays for all discrete outputs. Relays shall be rated a minimum of 10A at 120VAC. Relays shall have LED status indicating lights.

h. Discrete I/O modules shall be provided with LED status indicating lights on the front of the module. One LED shall indicate I/O status of the field device (yellow – input/output is “on”). The other LED shall indicate module operating status (steady green – normal operating state, flashing green – not performing connected communication, and steady red – module failure).

i. Analog I/O modules shall be provided with LED status indicating lights on the front of the module. One LED shall indicate the module calibration status (green flashing – in calibration). A second LED shall indicate module operating status (steady green – normal operating state, flashing green – not performing connected communication, and steady red – module failure).

2. Basic I/O Modules

The manufacturer shall have available a variety of I/O modules for the PLC. I/O modules shall be selected as required for the particular project application. Unless specified otherwise, basic I/O modules shall conform to the following:

a. Discrete Inputs

1) Voltage rating shall match circuit voltage. Isolated I/O shall be provided for applications where module interfaces with devices utilizing different sources of power.

2) Discrete input modules shall be provided with individually isolated digital inputs, or non-isolated digital inputs (8 points per group), depending upon the application.

3) Discrete input modules shall be sixteen (16) channel 120VAC.

b. Discrete Outputs

1) Voltage rating shall match circuit voltage. Isolated I/O shall be provided for applications where module interfaces with devices utilizing different sources of power.
2) Discrete output modules shall be provided with individually isolated digital outputs, or non-isolated and mechanically fused digital outputs (8 points per group), depending upon the application.

3) Discrete output modules shall be sixteen (16) channel 120VAC relay.

4) Provide one (1) external fuse per common or per isolated output. Provide blown fuse indication. Fuses shall be in accordance with module manufacturer’s specifications.

c. Analog Inputs

1) Analog input modules shall be provided with individually isolated analog inputs.

2) Analog input modules shall be eight (8) channel, 4-20mA DC (+/- 10V), with input impedance of 250 ohms per channel.

3) Analog input modules shall be provided with analog/digital (A/D) conversion resolution of 16 bits.

4) I/O chassis supplied power for powering connected field instruments.

d. Analog Outputs

1) Analog output modules shall be provided with individually isolated analog outputs.

2) Analog output modules shall be eight (8) channel, with each channel capable of driving a 4-20mA DC signal (+/- 10V) into a 0 to 600 ohm load.

3) Analog output modules shall be provided with digital/analog (D/A) conversion resolution of 16 bits.

e. Specialized I/O Modules:

1) Where required for the application, specialized I/O modules such as counter modules or high speed counter modules shall be provided.
2) All input/output signals and power supplies required for proper counter operation shall be provided.

D. Communications

1. Communications shall be capable of using Modbus, and open industry standard Ethernet/IP and OPC protocols.

2. The PLC shall be capable of peer-to-peer communications that provide for the direct transfer of process data between controllers without the use of gateways or servers.

3. Communication Capabilities: PLC chassis shall be capable of containing one or more communication modules to provide communication interfaces to other devices, including, but not limited to: remote work stations, HMIs, and PLCs by other manufacturers. As a minimum, the PLC shall support the following without the need for third-party modules:
   a. Ethernet (10/100MB).
   b. Serial protocols including Modbus and ASCII.

   The PLC shall be provided with an Ethernet module equipped with multiple ports (a minimum of 2 ports, unless specified otherwise). Each port shall be capable of communicating both TCP/IP and Ethernet/IP simultaneously. Modules requiring the ports to be configured for one protocol will not be acceptable. The communication module shall also support daisy chain wiring.

4. Surge protection shall be provided on all connections to communication ports.

E. Chassis

The PLC shall be provided with a chassis to mount the processor module, I/O modules, communication modules, and other applicable modules. The chassis shall be modular, capable of accepting any module into any slot. The chassis backplane shall provide a high speed communication path between modules and distribute power to each of the modules within the chassis. Modules shall be secured to the chassis via a screw connection. The chassis shall be available in various slot configurations, up to a total of 17 slots.
F. Power Supply Unit

PLC Power Supply Unit: Each PLC shall be provided with a regulated power unit designed to operate the PLC system. The power supply unit shall conform to the following:

1. Mount directly to the chassis and connect to the chassis backplane.

2. Provide power to:
   a. The PLC system, including the controller processor, I/O modules, communication modules, and other applicable modules.
   b. All associated two-wire field instruments.
   c. Other devices as indicated on the Drawings and/or Specifications.

3. Capable of supplying PLC system power when all the specified spare I/O capacity is utilized.

4. Sized to carry no more than 75 percent of total unit capacity under normal loads, including all spare capacity.

5. Provide constant voltage level DC distribution to all devices. Power distribution shall be immune to transients and surges resultant from input power noise.

6. A single power supply unit shall be provided for each chassis.

7. Unless specified otherwise, the input power to the power supply shall be 120VAC, +/- 10 percent, 60 Hz.

8. A separate line fuse shall be provided for each power supply unit.

G. Uninterruptable Power Supply (UPS)

Uninterruptable Power Supply (UPS): Unless specified otherwise, each PLC shall be provided with a UPS. The UPS shall conform to the following:

1. Ensure that transient power surges and dips do not affect the operation of the PLC system.

2. Utilize low maintenance, rechargeable, sealed batteries, maintained at a float point charge during normal power conditions.
3. Provide a synchronized 60 Hz sine wave output, in-phase with the utility line power sine wave. The sine wave output shall be synchronized during switching from utility AC power source to battery source and during switching from battery source back to utility AC power source. The UPS switch to and from battery in less than 4 milliseconds.

4. Provide silencing audible and visible alarms indicating utility AC line power failure and low battery.

5. Provide a serial port interface to communicate with the panel PLC. This interface shall provide information to alert Plant and/or District SCADA of a low battery warning, power alarm, or UPS failure.

6. Sized to sustain full power to the following loads for a minimum of 15 minutes after loss of primary power:
   a. PLC power supply unit, including all chassis mounted PLC modules and associated two-wire field instruments.
   b. PLC Human-Machine Interface.
   c. All power supplies furnished with the PLC and associated loads.

7. Unless specified otherwise, the input power to the UPS shall be 120VAC, +/- 10 percent, 60 Hz. Output power from UPS shall be 120VAC, +/- 5 percent, 60 Hz. An AC circuit breaker shall be provided for the line power to the UPS.

8. The UPS shall be Model Smart-UPS, as manufactured by APC, or equal.

2.04 HUMAN-MACHINE INTERFACE (HMI)

Where specified, each PLC shall be provided with a door mounted Human-Machine Interface (HMI). Unless specified otherwise, each HMI shall meet or exceed the following requirements:

A. Display Size: 12 inches

B. Display Type: Touchscreen, backlit, color TFT LCD, 18-bit color graphics

C. Operating System: Microsoft Windows CE 6.0 R3

D. Architecture: Open
Programmable Logic Controller
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E. Processor Frequency: 1.0 GHz

F. RAM: 512 MB

G. Internal Storage: 512 MB (80 MB non-volatile)

H. Operating Temperature: 0 - 55°C

I. Enclosure: NEMA 4X, 12, and 13

J. Input Power: 18-30VDC

K. Interfaces: 1-SDHC card slot (store data/reload interface applications), 1-USB-A and 1-USB-B (v2.0 high speed)

L. Communication Interfaces: 1-RJ45 10/100 MB, Auto MDI/MDI-X Ethernet port

M. Standard Software: FactoryTalk (Machine and Viewpoint) or equal, PDF Viewer, Active X Controls, Remote Terminal Control, FTP Server

N. Manufacturer/Model: Allen Bradley, PanelView Plus 7, or equal.

2.05 PLC ENCLOSURE AND APPURTENANCES

A. The PLC enclosure shall be of sufficient size to house all PLC and HMI hardware, power supplies, instruments, relays, devices, terminal blocks, wireways, and appurtenances as specified herein and required for each equipment system application.

B. Unless specified otherwise, PLCs located outdoors or indoors in corrosive or wet locations shall be provided with NEMA 4X enclosures constructed of Type 316 stainless steel. Unless specified otherwise, PLCs located indoors in non-corrosive and dry locations shall be provided with NEMA 12 enclosures. Enclosures shall be free-standing or wall mountable.

C. NEMA 4X enclosures shall be provided with solid exterior door(s) and interior hinged swing-out door(s) for mounting HMIs, instrument displays, lights, switches, pushbuttons, etc. All PLC enclosures shall be supplied with removable equipment mounting back panels and padlockable doors equipped with 3-point latching systems, inner drawing holders, and neoprene seals.
D. The interior and exterior of NEMA 4X stainless steel enclosures shall be unpainted. The interior of NEMA 12 enclosures shall be painted white and the exterior shall be painted gray. All enclosure interior mounting brackets, panels, and plates shall be painted white. Enclosures equipped with single doors shall be hinged to swing from right to left and shall be easily removable.

E. Each PLC panel shall be provided with LED lighting fixtures of sufficient size and quantity to provide 50 foot-candles of illumination within the panel. The lighting fixtures shall be horizontal LED tube type fixtures and shall be mounted to the top of the enclosure. The light fixtures shall be wired to a UL-approved switch mounted inside the panel.

F. Each PLC panel shall be provided with a duplex, 120VAC, 15A, 3-wire grounded GFCI type convenience receptacle.

G. Unless indicated otherwise on the Drawings, the light fixture(s) and convenience receptacle shall be powered from a separate voltage source than the PLC equipment.

2.06 INTERPOSING RELAY SUBASSEMBLIES

A. 24 VDC interposing relays shall be utilized on all digital outputs which are required to interact with the motor control center, VFDs, valves and external hardwired logic circuitry. Octal socket plug-in relays containing two form “C” 10 amp contacts shall be supplied. Each relay shall contain an internal LED indicating when the relay has been energized. Relay coils shall be wired to the load side (output) of the supplied PLC field terminal block and labeled to reflect the I/O address which drives it. A 1 amp, 100V (1N4001) surge suppression diode shall be wired across the relay coil socket pins. Interposing relay contacts shall be wired with yellow wire to the line side (input) of a separate isolated field terminal block dedicated to interposing signals. All wires between relay contacts and the interposing signal terminal block shall be labeled to reflect the relay/pin number.

B. Interposing relays shall be provided in subassemblies consisting of 4 relay sockets mounted onto an interposing relay mounting plate, and prewired with a color-coded wire harness for connection to terminal blocks, as described above. All hardware for mounting the subassembly into the PLC enclosure shall be provided, and a nameplate tag for relay identification shall be provided for each relay socket. Mounting of interposing relay subassemblies shall be simplified while maintaining the integrity of the enclosure’s NEMA rating, maintaining serviceability without the removal of other equipment, and preventing interference with the removal or serviceability of other equipment.
2.07 WIRING

A. All terminal blocks shall slide onto a single symmetrical steel DIN mounting rail. The terminal system shall be a finger-safe, multi-circuit (3 circuit minimum), compact, high-density design utilizing a stainless steel screw with nickel plated copper or brass pressure plate wire terminating construction. The terminal block system shall allow for installation ease where the addition of terminals simply requires sliding clear a space on the rail and snapping into place the new terminal modules. All terminals shall be rated for 600 volts with a maximum current of 20 amps, UL rated, and shall accommodate wires ranging between #24 to #12 AWG. All terminals shall have a place for marking the wire number associated with them. All terminal blocks shall be manufactured by Phoenix Contact, no substitutes.

B. All analog inputs and outputs shall be terminated onto fused signal isolation terminal modules in order to protect the PLC I/O modules from accidental field wiring errors, ground loops, disparate supply voltages and short circuits. Power feeds, external power supply outputs, and other power distribution wiring to external equipment shall be terminated on a fused terminal. All fused terminal blocks shall be equipped with fuses, including all spare terminal blocks.

PART 3 – EXECUTION

3.01 FABRICATION

A. The PLC chassis shall be mounted at the top of the enclosure back panel. Provide spacing around the PLC as required by the PLC manufacturer to ensure: adequate cooling, clearance space for cabling, and access for servicing. PLC communication ports, and memory card slots shall be accessible at all times. PLC lights shall be visible at all times when the enclosure door is opened.

B. The field wiring terminal block subassemblies shall be located at the bottom of the enclosure back panel for easy access and routing of external wiring.

C. The UPS and UPS power receptacle shall be located at the bottom of the enclosure.

D. The interposing relay subassemblies shall be mounted on the enclosure back panel or enclosure sides, whichever is most convenient for serviceability and panel size minimization while maintaining the NEMA rating. All relay sockets shall be prewired to terminals as described above.
E. I/O modules shall be prewired with cable subassemblies to terminal blocks with color-coded (individually shielded pairs for analog signals) and neatly routed in an orthogonal fashion along the bottom of the PLC modules, panel sides and top of the terminal block subassemblies. Slotted wire ducts with removable covers shall be used for wire and cable routing. The number of cable subassemblies and type shall correspond to the number and type of I/O.

F. Each PLC component shall include a clearly visible faceplate with appropriate data such as the manufacturer’s model number. In addition, nameplates engraved with the name/function of each PLC component shall be provided. Each nameplate shall be mounted adjacent to the respective component in a clearly visible location.

G. Each I/O point shall be identified on the door of the PLC I/O module.

H. All cables and connectors required for proper operation of all PLC components and accessories shall be furnished by the manufacturer, and shall be factory installed and tested.

3.02 INSTALLATION

A. Install the PLC panel in the location shown on the Drawings. Installation shall be in accordance with the manufacturer’s written installation instructions and as specified herein.

B. The PLC panel shall be rigidly support, plumb and level, and in such a manner as to provide accessibility and freedom from interference with other equipment, piping, or electrical work.

C. Install free-standing PLC panels on a 3-inch high concrete housekeeping pad.

D. Anchor panels in accordance with the manufacturer’s recommendations, and equipment seismic anchorage calculations/details (where specified).

E. All field wiring and cabling shall be connected to the PLC field terminal blocks in accordance with the approved shop drawings.

F. All grounding shall be connected as shown on the approved shop drawings.
3.03 FIELD QUALITY CONTROL

The ICS or packaged equipment system manufacturer shall provide a qualified service representative to perform the following:

A. Inspect the PLC, wiring, components, connections, and equipment installation. Perform all necessary pre-testing, operational checks, and adjustments of the supplied programmable controller, components, and equipment to ensure that the PLC is ready for operation.

B. Assist in field testing of PLC and equipment system, including all programming for monitoring and control of the equipment.

C. Provide a written report documenting all field testing and results.

D. Provide written certification that the PLC system has been properly installed, started up, fully tested, and is ready for operation by the District.

3.04 FIELD TESTING

A. After the PLC system installation has been certified and all analog points have been tested and calibrated, the entire system shall be tested to verify that on discrete and analog inputs and outputs are functioning correctly.

B. I/O points shall be tested from end-to-end without simulation, to the maximum degree feasible without causing damage to the equipment. Simulated testing will only be allowed when no practical alternative exists.

C. SCADA workstations shall be verified for correctness at the same time as the PLC testing.

D. I/O checklists shall be provided by the ICS or packaged equipment manufacturer to record the test results, with a copy provided to the District upon completion of testing.

E. Upon completion of the individual I/O points, system operational testing shall be performed. System operational testing shall demonstrate proper operation of the various process systems monitored and controlled by the PLC, including automatic control modes and control system interlocks. All specified functional requirements shall be verified for compliance.

F. Tests that fail to demonstrate the required operation shall be repeated in their entirety after corrective action has been completed.
G. During system testing, the ICS or packaged equipment manufacturer shall have a representative onsite continuously who is capable of troubleshooting and modifying the control system programming.

H. Upon satisfactory completion of all field testing, the ICS or packaged equipment manufacturer shall submit a system testing report to the District documenting all performed testing and testing results.

3.05 TRAINING

A. Upon satisfactory completion of all field testing and commission procedures, the ICS or packaged equipment manufacturer shall provide the services of a factory trained representative to provide onsite training of District personal in the operating and maintenance of the furnished equipment.

B. Training shall include classroom and hands-on instruction. As a minimum, training shall address:

1. PLC system hardware overview.
2. PLC and HMI software overview.
3. Service and maintenance.
4. Troubleshooting.
5. Operation, including program initiation, changing set points, manual overrides, passwords, etc.

END OF SECTION 17010
# SPECIFICATIONS - DETAILED PROVISIONS

Section 17210 - Magnetic Flowmeters

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PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

Contractor shall furnish and install magnetic flowmeters and all appurtenant materials and equipment. Magnetic flowmeters shall be suitable for the services listed, complete and operable in accordance with requirements of the Contract Documents and in conformance with the manufacturer's recommendations.

1.02 PROJECT SPECIFIC REQUIREMENTS

Contractor shall furnish and install magnetic flowmeter(s) as shown on the Drawings, as specified in Section 17210.1, Detailed Magnetic Flowmeters, and as specified herein.

Section 17210.1 shall be utilized in conjunction with this Specification. Flowmeter location, service, nominal diameter, pressure rating, and flow range shall be as specified in Section 17210.1, and as shown on the Drawings.

1.03 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Division 11 – Equipment
2. Division 13 – Special Construction
3. Division 15 – Mechanical
4. Division 16 – Electrical
5. Division 17 – Instrumentation and Controls
1.04 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A. Shop Drawings

Contractor shall prepare and submit complete and organized information, drawings, and technical data for all equipment and components. All drawings shall be legible and reduced to a maximum size of 11” x 17” for inclusion within the submittal. Shop drawings shall include, but not be limited to, the following:

1. Detailed Bill of Materials for all equipment and components, listing: manufacturer's name, quantity, size, description, and catalog/part number.

2. Manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, illustrations, and data in sufficient detail to demonstrate compliance with Specification requirements. Manufacturer’s literature and data shall be marked to clearly delineate all applicable information and crossing out all inapplicable information.

3. Dimensional drawings for each meter size.


5. Diagrams showing meter grounding recommendations and grounding conductor/connection requirements (conductor size and connection type), including: connection from meter terminal box or signal converter (if integrally mounted) to grounding ring(s), connection between grounding rings, and connection from grounding rings to ground rod.

6. Meter cable product data sheets.

7. Manufacturer's application performance guarantee for each meter location, and recommendations for installation at each location.

B. Operation and Maintenance Manual

Contractor shall submit a detailed Operation and Maintenance Manual for all equipment and components specified herein and incorporated into the Work. The Operation and Maintenance Manual shall be provided in accordance with the requirements of the District's General Conditions, and Section 01430.
Operation and maintenance manuals shall include, but not be limited to, the following:

1. Equipment Performance Data and Drawings
   a. Detailed Bill of Materials for all equipment and components, listing: manufacturer's name, quantity, size, description, and catalog/part number.
   b. Manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, and illustrations.
   c. Dimensional drawings for each meter size.
   d. Electrical wiring schematics for flow sensor and signal converter/transmitter. Interconnection wiring diagrams between signal converters/transmitters and related equipment and materials.

2. Equipment Installation Requirements
   a. Complete, detailed installation instructions for all equipment and components.

3. Equipment Operation Data
   a. Complete and detailed operating instructions, including operator interface menus, programming, and setup parameters.
   b. Printed list of all final setup parameters for each flowmeter, including factory settings and any field modifications to factory settings.

4. Equipment Service and Maintenance Data
   a. Maintenance data shall include all information and instructions required by District’s personnel to keep equipment properly cleaned and adjusted so that it functions economically throughout its full design life.
   b. Unloading, handling, and long term storage requirements.
   c. Explanation with illustrations as necessary for each maintenance task.
   d. Recommended schedule of maintenance tasks.
   e. Troubleshooting instructions.
f. List of maintenance tools and equipment.

g. Recommended spare parts list.

h. Name, address and phone number of manufacturer and manufacturer's local service representative.

5. Manufacturer's Warranty

6. Provide a signed written certification report with the Final Operation and Maintenance Manuals, certifying that the magnetic flowmeters have been properly installed, calibrated and adjusted, and are suitable for satisfactory continuous operation under varying operating conditions, and meet all requirements specified in the Contract Documents.

1.05 COORDINATION

Flowmeters and control systems shall be designed and coordinated for proper operation with related equipment and materials furnished by other suppliers and manufacturers under other sections of these Specifications and where applicable, with related existing equipment. All flowmeter and control devices shall be applied in full conformity with the Construction Drawings and Specifications, and with the instructions and recommendations of the flowmeter manufacturer and the related equipment manufacturer.

Related equipment and materials may include, but not be limited to: valve actuators, chemical feed equipment, analytical measuring devices, supervisory control equipment (SCADA), telemetry, conduit, cable, and piping, as described in other Sections associated with the project and shown on the Drawings.

Interconnection wiring diagrams shall be prepared between the related equipment and the equipment furnished under this Section. Interconnection wiring shall provide all functions specified herein and/or shown on the Drawings.

PART 2 - PRODUCTS

2.01 GENERAL

The magnetic flowmeter shall consist of a flow sensor and a signal converter/transmitter. The flow sensor shall utilize Faraday’s Law of Electromagnetic Induction, to produce an electrical voltage that is proportional to the velocity of the flow of liquid through the sensor. The signal converter/transmitter shall be micro-processor based. Unless specified otherwise, the signal converter/transmitter shall be remote mounted.
2.02 FLOW SENSOR

A. Each flow sensor shall be provided with a flanged end flow tube and a non-conductive liner suitable for the liquid being metered. Unless specified otherwise, the flow tube shall be constructed of Type 304 stainless steel with stainless steel or carbon steel flanged ends. Flanges shall be ANSI Class 150 for meter sizes up to 24", and AWWA Class D for meter sizes larger than 24". Unless specified otherwise, liner material shall be hard rubber or polyurethane. Flow sensors exposed to water with a chlorine concentration of 10 ppm or greater, such as recycled water, shall be provided with Teflon liner material.

B. The field coils of the flow sensor shall be supplied with a precisely adjusted bi-polar direct current. Coil drive power shall be supplied by the signal converter/transmitter. The output signal from the flow sensor shall be fed through cable to the signal converter/transmitter. There shall be no electronic components in the flow sensor.

C. The flow sensor coil enclosure and cable connection housing shall be epoxy coated steel or epoxy coated aluminum. Plastic housings will not be acceptable.

D. Flow sensors shall be weatherproof NEMA 4X at a minimum. Meters installed underground or in a below grade vault shall be manufactured to NEMA 6P standards to enable the meter to be submerged up to 30 feet for 48 hours and up to 10 feet with continuous submersion. Meters rated NEMA 6P shall have remote transmitters in separate NEMA 4X enclosures. The interconnecting cables shall be installed at the factory and the termination box filled with a non-setting, transparent potting material.

E. When installed in metallic piping, the flow sensor shall be provided with integral grounding electrodes. When installed in lined or non-metallic piping, the flow sensor shall be provided with Type 304 stainless steel grounding rings (grounding electrodes will not be acceptable).

F. When installed in piping conveying raw sewage or sludge, the flow sensor shall be certified for use in Class I, Division 2 hazardous locations.

G. Flow sensor grounding electrode and sensing electrode material shall be compatible with the process fluid. Unless specified otherwise, electrodes shall be constructed of Type 316 stainless steel or Hastelloy C.

H. Unless specified otherwise, the flow sensor lining material shall be hard rubber or polyurethane. The flow sensor, including liner material, shall be certified in accordance with National Sanitation Foundation Standard 61 for use with potable water. Accuracy shall not be affected by cuts or scratches in the flow sensor liner.
I. The flow sensor shall be provided with multiple sensing electrodes to accurately measure mean velocity. The flow sensor shall be capable of accurately measuring slurries and water with entrained air. Accuracy of the flowmeter system shall be ±0.2% of rate. Accuracy shall be traceable to the US National Institute of Standards and Technology (NIST), and shall be guaranteed on-site for applications such as drinking water, raw sewage, and similar media, even with a permanent coating of raw sewage or similar on the electrodes. A NIST traceable calibration certificate shall be provided with each flowmeter.

J. The flow sensor shall incorporate an empty pipe detection feature, which shall cause the meter to register zero flow when the sensor is not full.

K. Unless specified otherwise, the flow sensor shall be rated for a minimum working pressure of 150 psig.

L. The flow sensor shall be suitable for operating temperatures ranging from -4°F to +122°F (minimum).

2.03 SIGNAL CONVERTER/TRANSMITTER

A. Unless specified otherwise, the signal converter/transmitter shall be remote mounted from the flow sensor. Where special signal cable is required and recommended by the manufacturer, the cable shall be supplied by the meter manufacturer. Supplier shall confirm the length and installation requirements. Where signal converter/transmitter location is not shown on the Drawings, each flowmeter shall be furnished with a minimum of 200 feet of signal cable.

B. The signal converter/transmitter shall be suitable for outdoor exposure and shall be rated NEMA 4X.

C. The signal converter/transmitter shall be provided with an alphanumeric, 3-line, 16-character (minimum), backlit display to indicate flow rate, totalized values, settings, and faults. Unless specified otherwise, the display shall indicate flow in gallons per minute and total flow in acre feet. All programming shall be accomplished through an integral keypad or touch screen operation and all programming shall be protected by a user-defined password. The signal converter/transmitter shall be provided with a fault and status log.

D. The signal converter shall be coordinated with the flow sensor selection for accurately measuring potable water, raw sewage, slurries, and water with entrained air.

E. The signal converter/transmitter shall be capable of measuring bi-directional flow and shall have three separate totalizers.
F. The signal converter/transmitter shall operate on 120V, 60 Hz supply power.

G. The signal converter/transmitter shall produce a 4-20 mA DC output signal into a minimum load of 800 ohms, linear to flow. Output shall be selectable as unidirectional or bi-directional. In addition, the signal converter/transmitter shall provide a digital scaled pulse output for external display/recording of flow rate or total flow.

H. Where indicated on the Drawings or in Section 17210.1, the signal converter/transmitter shall be provided with a positive zero circuit to register zero flow when pumping units are not operating. A closed external dry contact (generated by pump "off" or other similar equipment control signal) input to the signal converter/transmitter shall drive the meter output to zero.

I. The signal converter/transmitter shall be suitable for operation in ambient temperatures ranging from -4°F to +140°F (minimum).

J. Where located indoors, the signal converter/transmitter shall be wall mounted or flush panel door mounted as indicated on the Drawings.

K. Where located outdoors, signal converter/transmitter shall be suitable for mounting inside a NEMA 4X stainless steel enclosure, Hoffman, or equal. The stainless steel enclosure shall be provided with a swing-out door panel and back panel. The signal converter/transmitter shall be flush mounted on the swing-out door panel or back panel mounted with a cut-out in the swing-out door panel for the display. The enclosure shall be provided with side mounted air supply fan, side mounted louvered and filtered air supply and exhaust openings, 120V supply power circuit breaker for the signal converter and air supply fan, and fuses for each.

L. The signal converter/transmitter shall be capable of verifying the performance of the measuring system in the field without removing the meter tube from the process. The field verification feature shall be integral to the signal converter/transmitter and shall be capable of continuously monitoring electronic parameters within the flow meter and signal converter/transmitter. If any value deviates from an acceptable range, the signal converter/transmitter shall acknowledge the event and a relay shall be activated. A summary report of the verification shall be downloadable directly through the service port of the signal converter/transmitter or while logged onto the manufacturer's webserver for an Ethernet/IP capable signal converter/transmitter. The integral verification system shall be Endress+Hauser Heartbeat Technology, or equal.

M. Where specified, local service communication with the meter shall be capable via a RJ-45 port and an Ethernet cable regardless of the output. The signal converter/transmitter shall have integral webserver capabilities with an unique IP address.
2.04 MANUFACTURERS

Magnetic flowmeters and manufacturers shall be as follows (no substitutes):

A. Promag W 400 Electromagnetic Flowmeter, as manufactured by Endress+Hauser. Unless specified otherwise, the signal converter/transmitter shall be provided with the following input/output signal capabilities: HART/4-20 mA; frequency, relay, and status input (flexible module); and Ethernet/IP.

B. Electromagnetic Flowmeter WaterMaster FE_12 or FE_32 with full bore flow sensor and remote mount signal converter/transmitter, as manufactured by ABB. Unless specified otherwise, the signal converter/transmitter shall be provided with the following input/output signal capabilities: HART/4-20 mA, pulse, and contact output.

C. Electromagnetic Flowmeter Sensor SITRANS F M MAG 5100 W with MAG 6000 signal converter/transmitter, as manufactured by Siemens. Unless specified otherwise, the signal converter/transmitter shall be provided with the following input/output signal capabilities: 4-20 mA output, pulse/frequency, relay output, and MODBUS RTU/RS 485.

Model numbers supplied herein are provided for information purposes only, to assist Contractor in selecting equipment that conforms to the Specification and Drawing requirements. In case of any conflict between model numbers provided and the descriptive requirements specified herein, the descriptive requirements shall govern.

Manufacturers shall modify or supplement standard equipment to provide all features and capabilities specified herein.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation of magnetic flowmeters and signal converters/transmitters shall be in accordance with manufacturer's written instructions.

B. Wiring between flow sensors and remote mounted signal converters shall be supplied by the meter manufacturer.

C. All magnetic flowmeters shall be grounded per manufacturer's requirements. Contractor shall coordinate grounding between signal converter, flow sensor, grounding rings, and ground rod to ensure compliance with the manufacturer's recommended grounding procedures. Prior to start up, manufacturer shall provide written certification that the meter installation is in accordance with their requirements, including grounding.
D. Unless specified or shown otherwise, outdoor signal converters/transmitters shall be remote mounted within NEMA 4X stainless steel enclosures. The enclosures shall be mounted on stanchions adjacent to the respective meters.

3.02 MANUFACTURER'S WARRANTY

Manufacturer shall guarantee all equipment against defects in material and workmanship for a period of two years from date of project acceptance. During the warranty period, manufacturer shall provide all labor and material required to repair or replace defective equipment at no cost to the District.

END OF SECTION 17210
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The following magnetic flow measuring systems shall be provided:

<table>
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<th>Tag No.</th>
<th>Size</th>
<th>Range</th>
<th>Liner Material</th>
<th>Electrode Material</th>
<th>NEMA Rating Body/Transmitter</th>
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(A) NOTE: Liner/Electrode Material to be provided per manufacturer recommendations

END OF SECTION 17210.1
SPECIFICATIONS - DETAILED PROVISIONS
Section 17310 - Site Access System

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SITE ACCESS SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

Contractor shall furnish, and install the site access system and all appurtenant materials and equipment. Site access system shall be suitable for the services listed, complete and operable in accordance with the requirements of the Contract Documents and in conformance with the manufacturer’s recommendations.

1.02 PROJECT SPECIFIC REQUIREMENTS

Contractor shall furnish and install the site access system as shown on the Drawings, as specified in Section 17310.1, Detailed Site Access System, and as specified herein.

Section 17310.1 shall be utilized in conjunction with this Specification. Gate operator location, type, and appurtenances shall be as specified in Section 17310.1, and as shown on the Drawings.

1.03 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all Sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Division 2 – Fencing
2. Division 3 – Concrete
3. Division 5 – Metals
4. Division 16 – Electrical
1.04 STANDARDS AND CODES

All equipment and materials, including installation of same, shall meet or exceed the applicable requirements of the following standards and codes (latest edition):

A. Underwriters Laboratories (UL)

1. UL325: Standard for Door, Drapery, Gate, Louver, and Window Operators and Systems.


B. National Fire Protection Association

1. NFPA 70 - National Electrical Code (NEC)

1.05 SUBMITTALS

A. Shop Drawings

Contractor shall prepare and submit complete and organized information, drawings, and technical data for all equipment and components. All drawings shall be legible and reduced to a maximum size of 11” x 17” for inclusion within the submittal. Shop drawings shall include, but not be limited to, the following:

1. Manufacturer product literature, specifications, features and accessories, materials of construction, and data in sufficient detail to demonstrate compliance with Specification requirements. Manufacturer’s literature and data shall be marked to clearly delineate all applicable information and crossing out all inapplicable information.

2. Detailed drawings for each gate operator showing layout and dimensions of gate, gate operator, connections to gate, gate operator support foundation, vehicle sensor system, gate operator entry system, and conduit/wiring for gate operator and accessories. Drawings shall clearly show the precise location of each vehicle detector loop and lead-in cable, loop dimensions, number of detector loop cable turns, slot width and depth, and placement of cable within the slot.

3. Written confirmation that each proposed operator unit is adequate for the specified gate (size, weight, and required pull force).
4. Manufacturer requirements for gate operator support foundation(s), including minimum dimensions, concrete strength, and reinforcing steel. Manufacturer requirements for gate operator frame anchorage, including anchor bolt locations, size, and embedment depth.

5. Complete wiring connection diagram for each gate operator and accessories.

6. Gate operator safety literature and required warning signs. Warning signs shall be in compliance with requirements of UL325.

7. Copy of proposed equipment warranty, as specified in Part 1.07 herein.

B. Operation and Maintenance Manual

Contractor shall submit a detailed Operation and Maintenance (O&M) Manual for all equipment and components specified herein and incorporated into the Work. The O&M Manual shall be provided in accordance with the requirements of the District's General Conditions, Section 01430, and as specified herein.

The O&M Manual shall include, but not be limited to, the following:

1. Equipment Performance Data and Drawings
   a. Detailed Bill of Materials for all equipment, components, and appurtenances, listing: manufacturer’s name, quantity, description, and model/part number.
   b. Manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, and illustrations.
   c. Manufacturer’s data and drawings showing dimensions, physical configurations, installation and mounting details, and wiring schematics.
   d. Control diagrams and wiring interconnect diagrams for all equipment, associated field devices, and controls.

2. Equipment Installation Requirements
   a. Complete, detailed installation instructions for all equipment, components, and appurtenances.
3. Equipment Operation Data
   a. Complete and detailed instructions for adjusting all equipment settings, including: input power, motor current settings, torque settings, status and alarm signals, etc.
   b. Complete and detailed user manuals and operating instructions, including setup parameters for all controllers.
   c. Printed list of all final setup parameters for each controller, including factory settings and any field modifications to factory settings.

4. Equipment Service and Maintenance Data
   a. Maintenance data shall include all information and instructions required by District's personnel to keep equipment adjusted and calibrated so that it functions properly under the full range of operating conditions.
   b. Explanation with illustrations as necessary for each maintenance task.
   c. Recommended schedule of maintenance tasks.
   d. Troubleshooting instructions.
   e. List of maintenance tools and equipment.
   f. Recommended spare parts list.
   g. Names, addresses and phone numbers of all manufacturers and manufacturer's local service representatives.

5. Manufacturer Warranties

1.06 QUALITY ASSURANCE

A. All equipment furnished shall be of current design and manufacture that has been utilized in similar applications and environments.

B. Automatic gate operators shall be as manufactured by LiftMaster, DoorKing, or equal.
1.07 WARRANTY

Gate operators shall be warranted by the manufacturer for a period of two (2) years from date of acceptance by the District against defects in materials or workmanship. Defective part(s) shall be repaired or replaced at no charge, at the manufacturer’s option. The warranty shall be in printed form and shall be included in the Operation and Maintenance Manual.

PART 2 - PRODUCTS

2.01 AUTOMATIC SLIDE GATE OPERATOR

A. General

1. Contractor shall furnish and install automatic vehicular slide gate operators as specified in Part 1.02 (herein) and as shown on the Drawings. Each vehicular slide gate operator shall be provided complete with all drive and electrical components. Gate operators shall be heavy-duty industrial slide type openers, Model SL585 as manufactured by LiftMaster, or equal.

2. Vehicular slide gate operator unit shall automatically open and close V-track (roller) gates to provide convenience and security. Operator unit shall function with standard features, options, and accessories including, but not limited to: inherent primary and secondary entrapment protection devices; connection of contact or non-contact entrapment protection devices, radio controls, single and three button control stations, digital keypads, coded cards, vehicle detector loops, telephone entry systems, and revenue control equipment.

3. Unless specified otherwise, each gate operator unit shall operate on 115 VAC, single phase, 60 Hz power.

4. Unless specified otherwise, the gate operator shall be controlled by a card reader system. Card readers shall be provided by the Security System Subcontractor.

B. Design Criteria

1. Operator unit shall be sized as required for the specified V-track rolling gate and site conditions. Operator unit shall be completely assembled, pre-wired, and tested in the factory.
2. Contractor and operator unit manufacturer shall coordinate with gate manufacturer to insure that the selected operator and accessories will be suitable for the proposed gate. Operator unit shall open/close the gate at a rate not greater than 11 inches per second. Operator unit shall provide a minimum pull force of 75 pounds.

3. Operator unit supplier shall provide all required operator accessories and appurtenances, including vehicle sensing loops, entry system, and entrapment protection sensors, to ensure compatibility between accessories and operator and to provide sole source responsibility.

C. Mechanical Features and Components

Standard mechanical features and components shall include as a minimum:

1. Weather-resistant galvannealed steel cabinet with automotive type powder coat finish.

2. Lockable access panel for manual disconnect and adjustable limit switches.

3. Heavy duty worm gear operator with oil bath lubrication.

4. 1-inch diameter (minimum) solid steel output drive shaft with heavy-duty ball bearings.

5. Roller chain and drive sprocket with chain guide(s) and gate attachment brackets.


D. Electrical Features and Components

Standard electrical features and components shall include as a minimum:

1. High-starting torque, continuous duty 1/2 HP (minimum) motor, 115 VAC, 60 Hz, single phase with thermal overload protection.

2. Solid state controller with adjustable timers, LED indicators, and self-diagnostics.

3. Adjustable motor current sensing to detect obstructions, with separate adjustments for opening and closing directions.

4. Adjustable motor RPM sensing to detect obstructions, with separate adjustments for open and closing directions.
5. Allow connection of external devices such as access control systems.

6. Integral detector loop inputs compatible with exit, shadow, and interrupt loops.

7. Controller housed in separate control box.

8. Power input "On/Off" switch.

9. Built-in 120 VAC duplex power receptacle for accessories.

10. Transformer for low voltage power. Fuse protected 24 VAC and 24 VDC secondary power shall be available on a terminal strip to power accessory devices.

11. Adjustable precision snap-action type limit switches to control gate position.

12. Contacts for opening, closing, and reversing accessories, as well as contact and non-contact obstruction sensing devices. In addition, a dry contact for the gate in a closed position shall be provided for remote indication. The dry contact shall be rated for 5A at 120 VAC and shall be pre-wired to a terminal strip.

E. **Entrapment Protection Devices**

Each gate operator shall be provided with inherent entrapment protection devices which comply with Class III of UL Standard 325. Unless specified otherwise, the primary entrapment protection device shall be adjustable motor RPM sensing and the secondary entrapment protection device shall be adjustable motor current sensing.

### 2.02 AUTOMATIC SWING GATE OPERATOR

A. **General**

1. Contractor shall furnish and install automatic vehicular swing gate operators as specified in Part 1.02 (herein) and as shown on the Drawings. Each vehicular swing gate operator shall be provided complete with all drive and electrical components. Gate operators shall be heavy-duty industrial swing type openers, Model SW490 as manufactured by LiftMaster, or equal.
2. Vehicular swing gate operator unit shall automatically open and close swing gates to provide convenience and security. Operator unit shall function with standard features, options, and accessories including, but not limited to: inherent primary and secondary entrapment protection devices; connection of contact or non-contact entrapment protection devices, radio controls, single and three button control stations, digital keypads, coded cards, vehicle detector loops, telephone entry systems, and revenue control equipment. Unit shall operate on 115 VAC, single phase, 60 Hz power.

3. Unless specified otherwise, the gate operator shall be controlled by a card reader system. Card readers shall be provided by the Security System Subcontractor.

B. Design Criteria

1. Operator unit shall be sized as required for the specified swing gate and site conditions. Operator unit shall be completely assembled, pre-wired, and tested in the factory.

2. Contractor and operator unit manufacturer shall coordinate with gate manufacturer to insure that the selected operator and accessories will be suitable for the proposed gate. Operator unit shall open/close the gate at a rate not greater than 7 degrees per second. Operator unit shall provide a minimum pull force of 75 pounds.

3. Operator unit supplier shall provide all required operator accessories and appurtenances, including vehicle sensing loops, entry system, and entrapment protection sensors, to ensure compatibility between accessories and operator and to provide sole source responsibility.

C. Mechanical Features and Components

Standard mechanical features and components shall include as a minimum:

1. Weather-resistant galvannealed steel cabinet with automotive type powder coat finish.

2. Lockable access panel for manual disconnect and adjustable limit switches.

3. Cold rolled solid steel output drive shaft with heavy-duty ball bearings.

4. Gate operator arms and gate attachment brackets.

D. **Electrical Features and Components**

Standard electrical features and components shall include as a minimum:

1. High-starting torque, continuous duty 0.5 HP (minimum) motor for single leaf gate, or two (2) 0.5 HP (minimum) motors for double leaf gates, 115 VAC, 60 Hz, single phase with thermal overload protection.

2. Solid state controller with adjustable timers, LED indicators, and self-diagnostics.

3. Adjustable motor current sensing to detect obstructions, with separate adjustments for opening and closing directions.

4. Adjustable motor RPM sensing to detect obstructions, with separate adjustments for open and closing directions.

5. Allow connection of external devices such as access control systems.

6. Integral detector loop inputs compatible with exit, shadow, and interrupt loops.

7. Controller housed in separate control box.

8. Power input "On/Off" switch.

9. Built-in 120 VAC duplex power receptacle for accessories.

10. Transformer for low voltage power. Fuse protected 24 VAC and 24 VDC secondary power shall be available on a terminal strip to power accessory devices.

11. Adjustable precision snap-action type limit switches to control gate position.

12. Contacts for opening, closing, and reversing accessories, as well as contact and non-contact obstruction sensing devices. In addition, a dry contact for the gate in a closed position shall be provided for remote indication. The dry contact shall be rated for 5A at 120 VAC and shall be pre-wired to a terminal strip.

E. **Entrapment Protection Devices**

Each gate operator shall be provided with inherent entrapment protection devices which comply with Class III of UL Standard 325. Unless specified otherwise, the primary entrapment protection device shall be adjustable motor RPM sensing and the secondary entrapment protection device shall be adjustable motor current sensing.
2.03 ACCESSORIES

A. Card Readers (By Others)

1. Contractor shall provide card readers as specified in Part 1.02 (herein) and as shown on the Drawings. Each card reader shall be pedestal mounted for operation of an automatic gate operator at each entry point as shown on the Drawings. Card readers shall be suitable for outdoor exposure.

2. Card readers shall be furnished by the Security System Subcontractor. Card readers shall be suitable to read existing magnetic cards for District personnel. Card reader access control system shall be connected to a microwave radio communication system to permit card reader recognition from District's central computer system.

B. Vehicle Sensor System

Unless specified otherwise, each gate operator shall be provided with a vehicle sensor system. Each vehicle sensor system shall consist of in-ground vehicle detectors loops for entrance and exit, lead-in cables, appurtenances, and gate operator integral control inputs for detector loops.

1. Detector loop cable shall be #14 AWG (minimum), stranded copper, single conductor, with cross-linked polyethylene insulation and suitable for direct burial. Loop size and number of turns shall be as determined by the gate operator manufacturer for vehicles ranging in size from small automobiles to large high bed trucks. A sufficient turns shall be provided to ensure the loop functions properly with the gate operator detector loop controls. The detector loop cable shall be continuous (no splices).

2. Lead-in cable shall be #16 AWG, stranded tinned copper, twisted pair, with aluminum/polyester shield, tinned copper drain, and polyethylene insulation. Lead-in cable shall be twisted four times per foot, minimum.

C. Photoelectric Entrapment Protection Sensors

1. Where specified, non-contact photoelectric sensors for entrapment protection shall be provided.

2. Photoelectric sensors shall include separate transmitter and receiver units, mounting arms, wiring, and appurtenances. Sensors shall prevent gate closure on obstructions (pedestrians and vehicles) within its path.
D. Card Reader Pedestals

1. Where specified, one (1) or two (2) tiered free standing pedestals shall be provided for card readers. Card reader pedestal location(s) shall be as shown on the Drawings.

2. Pedestals shall be constructed of 2" x 4" rectangular steel tubing with an 8" square base plate with integral conduit stub-up hole centered in steel tubing to conceal conductors. A steel base plate cover shall be provided to conceal anchor bolts. Each pedestal arm shall be provided with a stainless steel open sided housing for a mounting card reader, as specified herein. Each card reader housing shall be provided with solid back plate sized to accommodate the proposed card reader, and solid top and sides to shield the card reader from direct sunlight exposure.

3. The single tiered pedestal arm and lower arm of the two (2) tiered pedestal shall be a suitable height for a standard pickup truck. The upper arm of the two (2) tiered pedestal shall be a suitable height for a large service truck.

4. Contractor shall coordinate pedestal design, fabrication, and construction with Security System Subcontractor. Prior to pedestal fabrication, Contractor shall confirm card reader housing heights with District. Pedestal shall be provided with a factory baked on powder coating. Color shall be as selected by District. Pedestal and card reader housings shall be as manufactured by Engineered Parking Systems, or equal.

E. Building Emergency Access Boxes

1. Where specified, provide an emergency access box located outside of the building, as shown on the Drawings.

2. The emergency access box shall be wall mounted directly adjacent to the designated building door. The emergency access box shall be Knox Box Series 3200, Hinged Door Model as manufactured by the Knox Company (no substitutes).

3. Manufacturer information and location for the emergency access box (Knox Box) shall be submitted by the Contractor to the City or County Fire Department (as applicable) for approval.

F. Site Emergency Access Switches

1. Where specified, provide a site emergency access switch located outside of the automatic gate, as shown on the Drawings.
2. The emergency access switch shall be directly wired to the gate operator to automatically open and close the gate. In addition, the switch shall be wired to the security control panel provided by the Security System Subcontractor to indicate alarm/status. The emergency access switch shall be Knox Key Switch 3500 Series, Model 3502 as manufactured by the Knox Company (no substitutes).

3. Manufacturer information and location for the emergency access switch (Knox Key Switch) shall be submitted by the Contractor to the City or County Fire Department (as applicable) for approval.

PART 3 – EXECUTION

3.01 FACTORY INSPECTION AND TESTING

A. Manufacturer shall inspect and test each automatic gate operator at the factory to assure smooth, quiet operation.

B. Manufacturer shall test all gate operator control inputs and safety features to ensure proper function.

3.02 INSTALLATION

Contractor shall install the site access system, including gate operators and accessories in accordance with manufacturer's written installation instructions and approved shop drawings, UL Standards, and as indicated on the Drawings and specified herein. Contractor shall connect all necessary electrical power and control wiring, including furnishing of all necessary materials in addition to that provided with the specified equipment. Wiring materials and installation shall be in accordance with the requirements of Section 16050 and as shown on the Drawings.

A. Contractor shall provide a NEMA 4X stainless steel junction box directly adjacent to gate operator for supply power and remote communication conduits, as shown on the Drawings. Provide PVC coated flexible conduit between junction box and gate operator.

B. Contractor shall install entrance and exit vehicle sensor system detector loops for each gate operator. Unless specified otherwise, detector loops shall be placed in slots saw cut into the pavement. Detector loop location and dimensions shall be in accordance with the manufacturer's approved shop drawings. Slot width and depth shall be as determined by the gate operator manufacturer. Detector loop cable shall be placed into the slots and filled with epoxy in accordance with the manufacturer's written instructions.
Transition from detector loop cable to lead-in cable shall be in a precast concrete handhole located directly adjacent to the driveway. Lead-in cable shall be installed in PVC-RGS conduit from the handhole to the gate operator foundation. Conduit shall be stubbed up through the foundation, directly beneath the gate operator and aligned with the operator terminal box.

C. Contractor shall install a 3/4” diameter x 10' long copper clad ground rod extending through the gate operator support foundation for operator unit grounding. The operator cabinet enclosure shall be bonded to the ground rod with a #6 AWG bare copper conductor.

D. Contractor shall install photoelectric sensors (where specified) per manufacturer's written instructions.

E. Contractor shall install all warning signs securely with stainless steel fasteners and within view of both sides of the gate, as required by the manufacturer and UL 325.

F. Contractor shall coordinate locations of card reader mounting pedestals with District. The final location of each card reader mounting pedestal shall be confirmed in the field with the District’s Inspector.

G. Prior to equipment operation, Contractor shall provide initial lubrication of all mechanical components, check all belts/chains and other moving parts for alignment and tolerances in accordance with the manufacturer’s written instructions.

3.03 STARTUP AND TESTING

A. Contractor shall arrange for a qualified representative of the manufacturer to inspect the installation and perform start-up of the equipment and demonstrate required performance to the satisfaction of the District.

B. Manufacturer’s representative shall adjust the gate operator and accessories in accordance with the equipment installation manual and shall test the adjustments to verify correct settings for the installation. Each entrapment protection provision shall be tested separately and independently with the other entrapment protection provisions defeated.
3.04 INSTRUCTION

After the equipment has been installed, adjusted, tested, and placed in satisfactory operating condition, the equipment manufacturer shall provide instruction of District personnel in the use and maintenance of the equipment. Contractor shall give the District formal written notice of the proposed instruction period at least two weeks prior to commencement of the instruction period. Scheduled training shall be at a time acceptable to the District and the manufacturer. During this instruction period, the manufacturer shall address details of operation, routine maintenance, repair, and special equipment features. Manufacturer shall thoroughly address all items in the equipment operation and maintenance manual. Unless specified otherwise, one (1) hour of instruction shall be provided.

END OF SECTION 17310