

SET NO. _____

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**MWWTP
BLEND TANK AREA
ODOR AND GRIT IMPROVEMENTS**

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CONTRACT DOCUMENTS

VOLUME II-A OF III

TECHNICAL SPECIFICATIONS
(DIVISIONS 02-26)

JANUARY 2024

SPECIFICATION SD-409



EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT NO. 1
OAKLAND, CALIFORNIA

Bids will be opened at 1:30 pm, Wednesday, April 17, 2024 in the Board Room,
Second Floor of the District's Administration Building, 375 11th Street, Oakland, California

SECTION 00 01 07

PROFESSIONAL SEALS

The following design professionals have signed and sealed the original specifications for this project in accordance to the List of Specification Sections.

| | |
|---|---|
| <p>CIVIL ENGINEER</p>  <p>GARIN D. WARREN (GDW) EBMUD California License C 65259 Expiration Date: September 30, 2025</p> | |
| <p>CIVIL ENGINEER</p>  <p>MICHAEL WALKOWIAK BROWN AND CALDWELL California License C 54710 Expiration Date: December 31, 2025</p> | <p>CIVIL ENGINEER</p>  <p>DAN GAGNE BROWN AND CALDWELL California License C 63095 Expiration Date: June 30, 2024</p> |
| <p>ELECTRICAL ENGINEER</p>  <p>ROBERT MAC EBMUD California License E 16072 Expiration Date: December 31, 2025</p> | <p>ELECTRICAL ENGINEER</p>  <p>SUNDARA RAJAN PUTHUVEEDI PALANI BROWN AND CALDWELL California License E 19153 Expiration Date: June 30, 2024</p> |

| SPECIFICATION SECTION AND TITLE | DESIGN PROFESSIONAL SEAL BY |
|--|-----------------------------------|
| DIVISION 00 – PROCURMENT AND CONTRACTING DOCUMENTS – ALL SECTIONS | GDW |
| DIVISION 01 – GENERAL REQUIREMENTS – ALL SECTIONS | GDW |
| DIVISION 02 – EXISTING CONDITIONS – ALL SECTIONS | MW |
| DIVISION 03 – CONCRETE – ALL SECTIONS | DG |
| DIVISION 05 – METALS – ALL SECTIONS | DG |
| DIVISION 06 – WOOD, PLASTICS, AND COMPOSITES – ALL SECTIONS | MW |
| DIVISION 09 – FINISHES – ALL SECTIONS | MW |
| DIVISION 22 – PLUMBING – ALL SECTIONS | MW |
| DIVISION 23 – HEATING, VENTILATION, AND AIR CONDITIONING – ALL SECTIONS | MW |
| DIVISION 26 – ELECTRICAL – ALL SECTIONS | SRPP |
| DIVISION 27 – COMMUNICATIONS – ALL SECTIONS | RM |
| DIVISION 28 – ELECTRICAL SAFETY AND SECURITY – ALL SECTIONS | RM |
| DIVISION 31 – EARTHWORK – ALL SECTIONS | GDW |
| DIVISION 32 – EXTERIOR IMPROVEMENTS | |
| 32 12 16 Asphalt Concrete Paving | GDW |
| 32 17 23.13 Pavement Markings and Traffic Signage | GDW |
| 32 31 11 Gate Operators | RM |
| DIVISION 40 – PROCESS INTEGRATION | |
| 40 05 01 Piping Systems | MW |
| 40 05 06.16 Piping Connections | MW |
| 40 05 06.23 Expansion Joints and Flexible Hose | MW |
| 40 05 07 Hangers and Supports for Process Piping | MW |
| 40 05 07.13 Seismic Restraints for Piping | MW |

| SPECIFICATION SECTION AND TITLE | | DESIGN PROFESSIONAL SEAL BY |
|---|---|------------------------------------|
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| 40 05 17 | Copper Process Pipe and Tubing | MW |
| 40 05 24 | Steel Process Pipe | MW |
| 40 05 31.13 | Solvent Cement Welded PVC and CPVC Pressure Pipe | MW |
| 40 05 60 | Valves | MW |
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| 40 05 63.02 | Ball Valve, Bronze-Brass, Full Port | MW |
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| DIVISION 44 – POLLUTION AND WASTE CONTROL EQUIPMENT – ALL SECTIONS | | MW |

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MWWTP BLEND TANK AREA ODOR AND GRIT IMPROVEMENTS

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CONSTRUCTION SURVEYING

PART 1 - GENERAL

1.1 SCOPE OF WORK

- A. Project field surveying responsibility.
1. By District:
 - a. The Engineer will provide one benchmark and baseline near or on the site of the work.
 2. By Contractor: Employ the services of a Registered Land Surveyor in the State of California to establish all lines and grades for this project from District provided benchmarks and to include but not limited to the following activities note below:
 - a. Project Horizontal and Vertical control monumentation.
 - b. Provide one set of offset stakes to establish all lines and grades prior to construction of all open trench pipelines and appurtenances at 25-ft increments through curves of radius shorter than 500 feet and 50 feet for other curves and tangents, and at all defined breaks in grade. Offset stakes not to exceed 17 feet from centerline of pipe alignment.
 - c. Provide one set of stakes as requested for other pipeline appurtenances as indicated on the drawings.
 - d. Provide one set of stakes for required earthworks (slope or area grading) as indicated on the drawings, at an offset determined by the Engineer.
 - e. Provide one set of finished grade stakes for curbs, paved surfaces or walkways as shown on the drawings.
 - f. Provide one set of stakes for sewer, storm drain, structures or other project work as shown on the drawings.
 - g. Protect all stakes and monuments. Contractor shall preserve any monuments and or benchmarks noted in the area. Any re-establishment of destroyed monuments to be at the contractor's expense.
 - h. Transfer of grades from rough grade or finish grade stakes, grade checking as grading progresses.

- i. Staking for temporary works, including but not limited to: temporary earthworks, fencing, street detour components, parking area and street striping, and signs.
 - j. Setting the position (batter boards) of all excavation shoring, including but not limited to pits surrounding pipe tie-in work.
 - k. All other field surveys not explicitly stated above.
 - l. Survey all portions of the work as noted in specification 01 78 39.
- B. Related Sections:
- 1. Section 00 73 00 – Supplementary General Conditions, Article 3.
 - 2. Section 01 78 39 – Record Drawings.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 SUBMITTALS

- A. Listing with coordinates and elevations of all monuments added, moved, or demolished.
- B. CAD file of field survey information.

END OF SECTION

SECTION 02 41 13

SELECTIVE SITE DEMOLITION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work includes: Perform selective demolition including removal and disposal of finishes, paving, concrete, piping, conduit, tubing, supports, control panels, instruments, devices, mechanical equipment and other work as shown on the drawings and as specified herein.
- B. Related work specified elsewhere:
 - 1. Section 01 35 13 – Special Project Procedures
 - 2. Section 01 35 44 – Environmental Requirements

1.2 JOB CONDITIONS

- A. Promptly repair damages caused to adjacent facilities by demolition operations at no cost to the District.
- B. Maintain existing utilities indicated to remain, keep in service, and protect against damage during demolition operations.
- C. Provide interior and exterior shoring, bracing, and support to prevent movement, settlement or collapse of structures and adjacent facilities to remain.
- D. Blasting is not permitted.

1.3 SUBMITTALS

- A. Submit Construction and Demolition Waste Disposal Plan in accordance with Section 01 35 44.
- B. Submit demolition plan showing schedule of phased demolition, as part of and consistent with the progress schedule specified in Section 01 32 00, hazard control methods, and method of demolition proposed at each site.
- C. Submit plan on methods and materials to be used to protect operating equipment during demolition operations for the Engineer's approval.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 GENERAL

- A. Demolition operations shall be conducted in accordance with Article 31 of the Construction Safety Orders, Title 8, California Code of Regulations.
- B. Conduct demolition operations and removal of debris to ensure minimum interference with roads, walks, and other adjacent occupied or in-use facilities to remain as shown on the drawings.
- C. Ensure safe passage of persons around area of demolition. Conduct operations to prevent injury to adjacent buildings, structures, other facilities, and persons.
- D. Use water sprinkling, temporary enclosures, and other suitable methods to limit dust and dirt dispersion. Clean adjacent structures and improvements of dust, dirt, and debris caused by demolition operations.
- E. Remove, handle, and dispose of off-site, in a safe, appropriate, and lawful manner, and in accordance with Site Safety and Health Plan, all materials and equipment that are required to be removed under this contract.

3.2 PREPARATION

- A. Utilities:
 - 1. Notify District or appropriate utilities to turn off affected services before starting demolition.
 - 2. Remove abandoned utility lines exposed by demolition excavation.

3.3 SALVAGEABLE ITEMS

- A. Existing materials and equipment removed in the execution of the work and designated for reinstallation shall be fully protected until reinstalled.
- B. All reasonable effort shall be made to remove and preserve such designated materials and equipment to be reinstalled in an undamaged condition.
- C. Equipment and materials designated to be reinstalled shall be stored and protected at the work site or other location as designated by the Engineer.
- D. The following items shall be removed and preserved for re-installation:
 - 1. Blending Tank Area FRP Vessels
 - a. Iron Oxide Vessel
 - b. Biofilter Vessel
 - c. Carbon Adsorber Vessel

2. FOG Tank Area FRP Vessels
 - a. Biofilter Vessel
 - b. Carbon Adsorber Vessel
3. Blending/FOG Tank Area Degritting Equipment
 - a. Degritting Cyclone-Classifer with control panel
 - b. Double Disc Pump with control panel and VFD
 - c. Selected valves as indicated on drawings
 - d. Selected instruments and devices as indicated on drawings
4. NOT USED.

3.4 DEMOLITION

- A. Drawings define minimum portions of structures, utilities, and equipment to be removed. Unless otherwise shown, rough cuts or breaks may be made exceeding limits of demolition shown.
- B. Remove material from existing improvements as required to permit connection of new work. Avoid both damage to the portion to remain, and interference with the use and operation of existing structures and utilities.
 1. Pavement to be removed shall be saw cut to a uniform line prior to removal.
 2. Shut off, cap, or otherwise protect existing public utility lines in accordance with the requirements of the public agency or utility having jurisdiction.
 3. Completely remove all materials designated for removal as shown on the drawings.
- C. Remove all materials associated with existing equipment that is to be removed or relocated.
- D. Cut off concealed or embedded piping, conduit, boxes, reinforcing steel, anchor bolts, or other materials a minimum of 3/4" below the final finished surface.
- E. Patch existing surfaces to create a neat, smooth appearance. Use non-shrink grout to patch concrete or masonry surfaces. Use like materials for other surfaces.
- F. Demolition work shall include media and internal components of existing odor control vessels that cannot be reused.

3.5 DISPOSAL OF DEMOLISHED MATERIALS

- A. Remove, handle, and dispose of off-site, in a safe, appropriate and lawful manner, and in accordance with Section 01 35 44, all materials that are required to be removed under this contract.
- B. Dispose of media in existing odor control units in a lawful manner. Existing media is not known to be hazardous. District will test media prior to demolition to confirm if it is not hazardous. If the media is found to be hazardous, District will direct Contractor to manage disposal of hazardous waste using the hazardous waste cost allowance as specified in Section 01 21 00.
- C. Underground conduits, pipes, and drainage facilities that are to be demolished shall be removed flush with any excavation and a 0.5 foot thick plug of concrete placed securely in the pipe end to provide closure.
- D. Burning of removed materials is not permitted on the site.

END OF SECTION

SECTION 03 01 30.61

RESURFACING OF CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included: Resurfacing of existing concrete surfaces. This section shall apply to areas identified on the Drawings requiring “resurfacing,” “resurfacing mortar.” or “repair concrete slab.” Contractor shall determine quantities of materials required for this work and shall include all costs for resurfacing of concrete in their bid. Assume an average additional thickness of no less than ½ inch thick resurfacing mortar on all surfaces in addition to any added thickness called out on drawings.
- B. Related Sections:
1. Section 03 01 30.62 – Concrete Repair
 2. Section 03 30 00 Cast-in Place Concrete
 3. Section 03 35 00 Concrete Finishing

1.2 REFERENCES

- A. American Society for Testing and Materials (ASTM):

| | |
|-------------|---|
| ASTM C 109 | Test Method for Compressive Strength of Hydraulic Cement Mortars – Modified |
| ASTM C 348 | Test Method for Flexural Strength of Hydraulic Cement Mortars |
| ASTM C 469 | Test Method for Static Modulus of Elasticity and Poisson’s Ratio of Concrete in Compression |
| ASTM C 882 | Test Method for Bond Strength of Epoxy Resin Systems Used with Concrete – Modified |
| ASTM C 1202 | Test Method for Electrical Indication of Concrete’s Ability to Resist Chloride Penetration |

- B. International Concrete Repair Institute

| | |
|-------------|--|
| ICRI 210.3R | Guide to Using In-situ tensile Pull-Off Tests to Evaluate Bond of Concrete Surface Materials |
| ICRI 310.1R | Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion |
| ICRI 310.2R | Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair |

1.3 SUBMITTALS

- A. Submit in accordance with Section 01 33 00 - Submittal Procedures.
- B. Product Data: Submit manufacturer's data completely describing resurfacing concrete materials and including storage instructions, installation instructions and MSDS sheets.
- C. Manufacturer's Mixing and Application Instructions.
- D. Application Equipment: List and describe all equipment proposed for the work with written certification that the equipment is in good condition for the intended service and in conformance with requirements of ACI 504R for wet mix application.
- E. References of applicators and manufacturers approval for quality control per paragraph 1.4.
- F. Manufacturer's certification of surface preparation per Paragraph 3.1 I.
- G. Independent Testing Engineer, concrete tensile pull-off test plan and certified test results per paragraph 3.6.

1.4 QUALITY ASSURANCE

- A. Applicator
 - 1. Three years of experience applying similar product as specified. Submit three references that the Contractor has demonstrated successful application of the specified product within the past two years. Provide name, address, and telephone number of the Owner for each application.
 - 2. Applicator shall be approved by the mortar manufacturer.
- B. The Contractor shall comply with the requirements of ACI 506R including but not limited to the crew qualifications and quality control.
- C. Manufacturer shall attend a pre-installation meeting and make periodic visits to the project site to provide inspection services and consultation during surface preparation and application of coatings. Manufacturer shall inspect the surface preparation; the equipment being used for and the procedures of application by the Contractor and shall submit written certification that the work is in accordance with the manufacturer's recommendations.
- D. Manufacturer Qualifications: The manufacturer of the specified resurfacing mortar shall have been in existence, for a minimum of 10 years.
- E. Allowable Tolerances: Deviation from plumb or level shall not exceed 1/8 inch within 10 feet in any direction, as determined with a 10-foot straight edge.

- F. Contractor's equipment to pump the concrete resurfacing mortar shall not be older than 10 years from the date of manufacture. Rebuilt pumps will not be accepted. Contractor shall provide equipment serial number for verification.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver the specified product in original, unopened containers with the manufacturer's name, labels, product identification, and batch numbers.
- B. Store and condition the specified product as recommended by the Manufacturer.
- C. Store materials subject to damage by dirt and moisture in a clean, dry location, off the ground and suitably protected.

1.6 SITE CONDITIONS

- A. Apply resurfacing mortar between 50 and 95-degrees Fahrenheit.
- B. Turn off forced ventilation and radiant heating systems and protect work against drafts during installation and minimum 72 hours after completion. Use indirect auxiliary heaters to maintain temperature in area. Vent temporary heaters to exterior.
- C. Follow manufacturer's recommendations regarding additional installation information (hot weather-drying conditions, or cold weather installation).

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Resurfacing Mortar: Sprayable, trowelable, shrinkage-compensated, one-component with silica fume, fiber reinforced, cementitious structural mortar with integral corrosion inhibitor, suitable for vertical and overhead applications. It must be compatible with proposed repair mortar (if different).
 - 1. Compressive Strength: ASTM C109
 - a. 1-day: 3,500 psi min.
 - b. 28-day: 9,000 psi min.
 - 2. Slant Shear Bond Strength: ASTM C882, Modified
 - a. 7-day: 1,500 psi min
 - b. 28-day: 2,500 psi min.
 - 3. Splitting Tensile Strength: ASTM C496
 - a. 7-day: 350 psi min.

- b. 28-day: 735 psi min.
 4. Flexural Strength: ASTM C348
 - a. 7-day: 650 psi min.
 - b. 28-day: 1100 psi min.
 5. Chloride Permeability: ASTM C1202
 - a. 28 day: < 500 coulombs
 6. Sulfate Resistance: ASTM C1012
 - a. 6 months: < 0.10%, or 1 year: < 0.06%
 7. Direct Tensile Bond Strength: ACI 503R, Appendix A
 - a. 7-day: 175 psi min.
 - b. 28-day: 300 psi min.
 8. Modules of Elasticity: ASTM C469
 - a. 28-day: 3.5 to 5 million psi
 9. Color: Concrete grey.
 10. Manufacturers: One of the following or equal:
 - a. BASF Construction Chemicals LLC, Shakopee, MN, “MasterEmaco S 488 CI”, 1(800)433-9517.Sika Corporation, Lyndhurst, NJ, “SikaQuick 1000”, 1(800)933-7452.
 - b. Or approved equal.
- B. Curing Compounds: As recommended by Manufacturer and water based in accordance with ASTM C-309.
- C. Finishing Aid/Evaporation Retarder: As recommended by the Manufacturer.
 1. BASF, Confilm.
 2. Sika, SikaFilm.
- D. Water: Potable.

PART 3 - EXECUTION

3.1 SURFACE PREPARATION

- A. General: Perform surface preparation in compliance with ICRI Technical Guide 310.1R “Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion.”
- B. Saw-cut perimeter of the area to be repaired to a minimum depth of 1/2”. Do not cut existing steel reinforcement. Verify the existing conditions of entire perimeter prior to beginning saw-cutting.
- C. Remove all unsound or deteriorated concrete, dirt, oil, grease, any existing coatings, and all other bond-inhibiting materials from the areas to be resurfaced. Remove a minimum depth of existing concrete as indicated on drawings (based on the original finished surface when new), but no less than 1-inch, and continue removal as required to expose sound aggregate and achieve minimum amplitude. Preparation work shall be done by high, or ultra-high pressure water blast, or other appropriate mechanical means approved by the Engineer to obtain an exposed aggregate surface with a minimum surface profile indicated below. Saturate the surface with clean water.
- D. Substrate shall have minimum amplitude of 1/4-inch. Limit the size of chipping hammers to 15 lbs. to reduce micro fractures.
- E. Roughness of surface shall be not less than Concrete Surface Profile (CSP) 6 as defined by International Concrete Repair Institute (ICRI 310.2R).
- F. Substrate shall be saturated surface dry (SSD) with no standing water during application.
- G. Where reinforcing steel with active corrosion is encountered, inspect and repair the reinforcing steel per Section 03 01 30.62, CONCRETE REPAIR.
- H. Thoroughly clean the roughened surface and exposed reinforcement of rust, dirt, loose chips, and dust using high pressure water.
- I. The Contractor shall dispose of sediments from concrete surface preparation in accordance with the Construction and Demolition Waste Disposal Plan per Section 01 35 44 - Environmental Requirements.
- J. Manufacturer’s Certification: Following surface preparation and prior to application of the resurfacing mortar, the manufacturer’s representative shall inspect the surface preparation and submit written certification that the work is in accordance with the manufacturer’s recommendations.

3.2 MIXING

- A. Comply with mortar manufacturer’s recommendations for water quantity and mixing procedures.

3.3 APPLICATION

- A. Apply resurfacing mortar by low-pressure wet spray or hand-trowel to thickness or elevation indicated on drawings. Where thickness or elevation is not specified, apply resurfacing mortar to re-establish or align with the original finished concrete surface. Actual applied thickness will be greater.
- B. Apply mortar in accordance with manufacturer's instructions.
- C. Use flat edge steel trowel.
- D. Do not fill or cover existing expansion and control joints with mortar. Replace joint material to match and connect with the existing adjacent joints.

3.4 FINISHING

- A. Level surface of mortar using a float or screed.
- B. Apply final finish when mortar has begun to stiffen.
- C. Provide smooth steel trowel finish (S3) for walls and underside of roof slab and non-skid finish (S4) for top of roof slab and floor slab.
 - 1. S3 Finish: Steel trowel finish free from trowel marks. Provide smooth finish free of all irregularities.
 - 2. S4 Finish: Steel trowel finish, without local depressions or high points, followed by light hair broom finish. Do not use stiff bristle brooms or brushes. Broom parallel to slab-drainage. Provide resulting finish that is non-skid and acceptable by the Engineer.
 - 3. For surfaces to be coated:
 - a. Coordinate finish with the coating manufacturer's requirements.
 - b. Finished surface shall not have any reinforcing fibers protruding that may impact the performance of the coating.

3.5 CURING

- A. Protect fresh mortar from premature evaporation. Cure finished resurfacing mortar immediately after finishing by one or both of the following methods as recommended by Manufacturer and in compliance with ACI – 308R recommendations for Portland cement concrete.
 - 1. Keep area continuously moist with fine mist of water as soon as mortar surface has hardened (thumb print hard), for a minimum of three days.

2. Apply curing compound as recommended by Manufacturer and in accordance with ASTM C-309. Curing compound shall only be allowed for the topcoat of the resurfacing material. Solvent based curing compounds shall not be allowed.
- B. Protect newly applied material from direct sunlight, wind, rain and frost. Include protective tents as required to prevent sunlight from hitting all newly placed material for a minimum of 7 days after placement.
 - C. Do not use curing compound for mortar surface that will receive epoxy coating or remove the curing compound prior to coating.

3.6 FIELD TESTING

- A. Contractor shall employ an Independent Testing Agency to perform in-situ tensile pull-off tests to verify:
 1. Surface soundness of the existing concrete.
 2. Adhesion of mortar to the existing concrete surface.
 3. Tensile strength of mortar.
- B. Tests shall be made per the manufacturer's recommendations and requirements of ICRI Guideline No. 210.3R.
 1. Samples shall be core drilled to a minimum either 1 inch depth or one-half of core diameter, whichever is greater, into the existing substrate prior to testing. Do not cut existing reinforcing steel.
 2. Mortar shall be cured for a minimum 14 days prior to testing.
 3. Pull-off required Strengths: 200 psi min. on substrate; 175 psi min. on mortar and bonding to substrate. No tests below 75% of the required strength.
- C. Numbers and Locations of Test
 1. Surface Soundness Test:
 - a. Two (2) tests for each 100 square feet of application area.
 2. Adhesion and mortar tensile strength Tests:
 - a. Two (2) tests for each 100 square feet of application area.
 3. Other locations determined as needed in field by Engineer.

D. Retest

1. Retest per ICRI Guideline when the average strength of test results is below the strength requirement or the test result of any single test is below 75% of the required strength.
2. Cost of retests shall be paid by Contractor.
3. Cost of retesting the substrate, that meets surface profile and preparation requirements as set forth in this Section, shall be paid by District.

E. Submit certified test results to District.

F. Repair

1. Make any repairs as needed when retest results fail to meet acceptance criteria.
2. Retest after repair. Repairs and retests shall be no additional cost to District.
3. The existing substrate shall be repaired as directed by Engineer. If surface profile and preparation meet requirements as set forth in this Section, cost of such repair shall be paid by District.

1.2 CLEANING

- A. Remove debris and excess material. Leave work site in a neat, clean condition.

END OF SECTION

SECTION 03 01 30.62

CONCRETE REPAIR

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included: Repairing damaged structural concrete including, but not limited to, cracks 1/8 inch wide and larger, spalled areas and unsound concrete surfaces.
- B. Related Sections:
 - 1. Section 03 01 30.61 – Resurfacing of Cast-in-Place Concrete
 - 2. Section 03 20 00 – Concrete Reinforcing
 - 3. Section 03 30 00 – Cast-in Place Concrete

1.2 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. ACI 546-14 Guide to Concrete Repair
 - 2. ACI 548.13-14 Specification for Bonding Fresh Concrete to Hardened Concrete with a Multi-Component Epoxy Adhesive
 - 3. ACI 562-16 Code Requirements for Assessment, Repair and Rehabilitation of Existing Concrete Structures
- B. American Society for Testing and Materials (ASTM) publications for standard test methods including: C 78, C 109, C 348, C 496, C 882 and C1202.
- C. International Concrete Repair Institute (ICRI):
 - 1. 310.1R – 2008 Guideline for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion
 - 2. 320.1R – 2019 Guideline for Selecting Application Methods for the Repair of Concrete Surfaces

1.3 QUALITY ASSURANCE

- A. Manufacturer Qualifications: The manufacturer of the specified product shall have been in existence, for a minimum of ten (10) years.
- B. Applicator Qualifications: Minimum of three (3) years of experience applying similar product as specified and approval of the mortar manufacturer.

- C. Allowable Tolerances: Deviation from plumb or level shall not exceed 1/8 inch within 10 feet in any direction, as determined with a 10-foot straight edge.

1.4 SYSTEM DESCRIPTION

- A. General: Structural repair concrete product(s) composed of cementitious materials and other admixtures capable of being placed in formed or unformed vertical and overhead applications, as well as on horizontal and all other sloped surfaces.
- B. Design Requirements:
 - 1. Suitable for performing in environments subject to corrosive attack by chlorides, sulfates and other constituents harmful to concrete and concrete reinforcing. Properties shall include low permeability, low-shrink and abrasion resistant.
 - 2. Provide repair mortars for either hand application or formed (pump or pour) application.
 - 3. Include mortars that can be placed in depths from 1/8 inch and are extendable to greater depths.
 - 4. Compatible with resurfacing mortar, per Section 03 01 30.61, when applied in, or adjacent to, areas that will be resurfaced.

1.5 SUBMITTALS

- A. Submit in accordance with Section 01 33 00 - Submittal Procedures.
- B. Product Data: Submit manufacturer's data completely describing structural repair concrete materials and including storage instructions, installation instructions and MSDS sheets.
- C. Certified Estimate of Quantity of Work: Prior to performing the concrete repair work under this Section, inspect areas designated for repairs to verify the quantities of concrete to be repaired. Spray paint limits of work for each area to be repaired and number each location. Submit a summary report indicating the area number, location, description, and estimated quantity. The District shall review and agree upon the total quantity prior to the start of work at each area.
- D. Certificates of Compliance for quality assurance per Paragraph 1.3.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver the specified product in original, unopened containers with the manufacturer's name, labels, product identification, and batch numbers.
- B. Store and condition the specified product as recommended by the Manufacturer.

- C. Store materials subject to damage by dirt and moisture in a clean, dry location, off the ground and suitably protected.

1.7 PROJECT CONDITIONS

- A. Hot Weather: ACI 305.
- B. Cold Weather: ACI 306.
- C. Do not place concrete repair mortar during precipitation unless adequate protection is provided.

PART 2 - PRODUCTS

2.1 REPAIR MORTAR SYSTEM

- A. Repair Mortar Hand Applied
 - 1. One-component, trowel-able or pourable, high strength with low permeability, structural repair mortar with integral corrosion inhibitor, suitable for vertical repairs.
 - a. Compressive Strength: In accordance with ASTM C 109:
 - 1) 1 day: 2,500 psi, minimum.
 - 2) 28 day: 7,500 psi, minimum.
 - b. Slant Shear Bond Strength: 1,800 psi minimum at 28 days, in accordance with ASTM C 882 Modified.
 - c. Splitting Tensile Strength: 550 psi minimum at 28 days, in accordance with ASTM C 496.
 - d. Flexural Strength: 770 psi minimum at 28 days, in accordance with ASTM C 348.
 - e. Color: Match adjacent concrete.
 - f. Extendable with coarse aggregates per manufacturer's recommendation for repair of thick section.
 - g. Manufacturers: One of the following or approved equal:
 - 1) BASF Construction Chemicals LLC, Shakopee, MN, "MasterEmaco S 466CI".
 - 2) Sika Corporation, Lyndhurst, NJ, "SikaRepair 223".

B. Repair Mortar Formed

1. Pump and pourable repair mortar. Cement based, high early strength, abrasion resistant, with integral corrosion inhibitor.
 - a. Compressive Strength: In accordance with ASTM C 109:
 - 1) 1 day: 2,000 psi, minimum.
 - 2) 28 day: 6,500 psi, minimum.
 - b. Slant Shear Bond Strength: 2,500 psi minimum at 28 days, in accordance with ASTM C 882 Modified.
 - c. Splitting Tensile Strength: 950 psi minimum at 28 days, in accordance with ASTM C 496.
 - d. Color: Match adjacent concrete.
 - e. Manufacturers: One of the following or approved equal:
 - 1) BASF Construction Chemicals LLC, Shakopee, MN, “MasterEmaco S 477CI”.
 - 2) Sika Corporation, Lyndhurst, NJ, “Sikacrete 211 SCC Plus”.

C. Surface Repair Mortar – Minor cosmetic repairs

1. Polymer-modified, cement based, fast-setting, non-sag mortar with integral corrosion inhibitor, suitable for vertical and overhead applications.
 - a. Compressive Strength: In accordance with ASTM C 109:
 - 1) 1 day: 2,000 psi, minimum.
 - 2) 28 day: 6,000 psi, minimum.
 - b. Slant Shear Bond Strength: 2,100 psi minimum at 28 days, in accordance with ASTM C 882 Modified.
 - c. Splitting Tensile Strength: 550 psi minimum at 28 days, in accordance with ASTM C 496.
 - d. Color: Match adjacent concrete.
 - e. Manufacturers: One of the following or approved equal:
 - 1) BASF Construction Chemicals LLC, Shakopee, MN, “MasterEmaco N 300 CI”.

2) Sika Corporation, Lyndhurst, NJ, “SikaTop 123 Plus”.

D. Anti-corrosion coating for reinforcing steel:

1. Manufacturers: One of the following or approved equal:
 - a. BASF Construction Chemicals LLC, Shakopee, MN, “EMACO P24.”
 - b. Sika Corporation, Lyndhurst, NJ, “Armatec 110 EpoCem”.

E. Epoxy Bonding Agent:

1. Compatible with repair mortar. Compatibility shall be approved in writing by the repair mortar manufacturer.
2. Manufacturers: One of the following or approved equal:
 - a. Sika Corporation, Lyndhurst, NJ, “Sikadur 32, Hi-Mod or Sikadur 32, Hi-Mod LPL”.
 - b. BASF Construction Chemicals LLC., Shakopee, MN, “MasterEmaco ADH 1090 RS or MasterEmaco ADH 326”.

F. Finishing Aid:

1. Compatible with repair mortar. Compatibility shall be approved by repair mortar manufacturer.
2. Manufacturers: One of the following or approved equal:
 - a. Sika Corporation, Lyndhurst, NJ, “SikaFilm.”
 - b. BASF Construction Chemicals LLC, Shakopee, MN, “Confilm.”

G. Water: Potable, clean, not detrimental to concrete.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Prepare estimate of quantities as required under Submittals prior to performing concrete repairs.
- B. Verify that concrete surfaces and exposed reinforcing are clean and free of contaminates.

3.2 PREPARATION

- A. Remove all loose and deteriorated concrete, cleaning with steel brush.

- B. Roughen and clean surfaces to receive product in accordance with manufacturer's recommendations and ICRI (minimum surface profile on concrete of +/- 1/8 inch.).
- C. Thoroughly clean reinforcement and other embedded items to remove laitance, loose rust, and other objectionable matter.
- D. Thoroughly wet wood forms, except coated plywood, and adjacent concrete at least one hour in advance of placing mortar as recommended by manufacturer; securely close cleanout end inspection ports; repeat wetting as necessary to keep forms damp.
- E. Damaged Concrete:
 - 1. Areas to be repaired shall be clean, sound, and free of contaminants. Saw cut perimeter 1/2 inch minimum. Do not cut existing reinforcing steel unless indicated on Drawings. Remove all loose and deteriorated concrete by mechanical means acceptable to the Engineer.
 - 2. Chip concrete substrate to obtain an exposed aggregate surface with a minimum construction surface profile of CSP-5 or CSP-6 in accordance with manufacturer's print instructions. The area to be repaired shall be not less than one inch in depth.
 - 3. Concrete removal shall extend along the reinforcing steel to locations along the bar that are free of bond inhibiting corrosion, and a minimum distance of 3 inches beyond where the bar is well bonded to surrounding concrete.
- F. Use the following procedures where reinforcing steel with active corrosion is encountered:
 - 1. Abrasive blast to remove all rust, scale and contaminants from the exposed reinforcing bar and achieve all prepared surfaces as recommended by anti-corrosion coating manufacturer.
 - 2. If more than half the diameter of the reinforcing bar is exposed, chip out all around the bar a minimum of 1/2 inch. The clearance chipped around the reinforcing bar must also equal or exceed the minimum placement depth of the accepted repair mortar.
 - 3. Inspect and determine section loss due to corrosion. Replace corroded reinforcing bar with a new bar of the same size where corrosion has depleted cross-section area by more than 15 percent. Splice new reinforcing bar to the existing bar or install dowels per details on the Drawings or as directed by the Engineer.

4. Coat all exposed reinforcing steel surfaces after they are prepared with anti-corrosion coating as recommended by manufacturer. Apply coating the same day after abrasive blasting. If flash rusting of the metal occurs before coating, re-blasting will be required.
- G. Treat cracks in the substrate at the area of patching or overlay work as directed by the Engineer.
- H. Restore (and if necessary extend) any existing control and/or expansion joints that occur through any concrete repair areas.
- I. Apply bonding agent in accordance with manufacturer's instructions to entire repair area prior to application of the repair mortar.

3.3 MIXING

- A. Mix in accordance with manufacturer's mixing instructions.
- B. Provide a mixture of white and regular cements as required to make a mortar that after curing 28 days will match adjacent concrete. When a mix has been selected for color match, batch all mortar by weight in accordance with the formula for the selected mix.

3.4 INSTALLATION

- A. Maintain substrate in a saturated, surface dry condition.
- B. For hand applications, a bond slurry coat is required.
- C. Apply repair mortar by low-pressure wet spraying or hand-troweling on vertical or overhead surfaces in depths ranging from 3/8" to 2".
 1. Vertical Applications: Do not exceed 2" thickness per lift.
 2. Overhead Applications: Do not exceed 1.5" thickness on first pass. For depths greater than 1.5", limit succeeding lifts to 1" thickness.
 3. Multiple Passes: Place succeeding lifts after repair mortar has developed initial set. Scarify the surface of the first lift to ensure integral bond between successive layers.
- D. Install in accordance with manufacturer's installation instructions.
- E. In accordance with ACI recommendations, apply concrete repair material only when ambient conditions of moisture, temperature, humidity, and wind are favorable for curing.
- F. Scrub mortar into substrate, filling all cracks, voids, and pores.
- G. Level surface of repair mortar using a float or screed.

- H. Apply final finishing aid when mortar has begun to stiffen using a wooden, plastic, or synthetic sponge float.
- I. For new construction, finish of repaired area shall match required finish for concrete being repaired. For existing concrete, finish of repair area shall match existing finish of concrete being repaired.
- J. Cure per manufacturer's recommendations. During the curing process, protect concrete repair from direct sunlight, rain, wind, or freezing as required. Keep sufficient covering on hand at all times for protection of repair concrete.

3.5 CLEANING

- A. Remove debris and excess material. Leave work site in a neat, clean condition.

END OF SECTION

SECTION 03 11 00
CONCRETE FORMING

PART 1 - GENERAL

1.1 SUMMARY

- A. Work included: Furnish and install formwork for cast-in-place concrete.
- B. Related Sections:
 - 1. Section 03 30 00 – Cast-in-Place Concrete
 - 2. Section 03 35 00 – Concrete Finishing.

1.2 QUALITY ASSURANCE

- A. Design Criteria:
 - 1. Formwork, including forms, falsework, shoring, bracing, and accessories such as ties, anchors, and hangers, shall be designed in accordance with Chapter 1 of ACI 347 - American Concrete Institute Standard Recommended Practice for Concrete Formwork.
 - 2. The design and construction of forms and form supports shall be subject to approval of the Engineer, but responsibility for their adequacy shall rest with the Contractor.
- B. Tolerances:
 - 1. Formwork shall be constructed and maintained as required to produce completed work within the tolerance limits specified in Chapter 2 of ACI 347.
 - 2. The following construction tolerances are hereby established and apply to finished walls and slabs unless otherwise shown:

| <u>Item</u> | <u>Tolerance</u> |
|--|---|
| Variation of constructed linear outline from the established position in plan. | In 10 feet: 1/4-inch; In 20 feet or more: 1/2 inch |
| Variation from the level or from the grades shown. | In 10 feet: 1/4-inch; In 20 feet or more: 1/2 inch |
| Variation in the thickness of slabs and walls. | Plus 1/2 inch, Minus 1/4-inch |
| Variation in the location and sizes of slabs and wall openings | Plus or minus 1/4-inch |

C. Source Quality Control

1. Forms: Verify that components pre-assembled offsite are satisfactory for the purpose. Verify, that designs, products and samples have been submitted for Product Review.

1.3 SUBMITTALS

- A. Submit detailed plans of the falsework proposed to be used to the Engineer for acceptance. Such plans shall be in sufficient detail to indicate the general layout, sizes of members, anticipated stresses, grade of materials to be used in the falsework, means of protecting existing construction which supports falsework, and typical soil conditions. Submit prior to start of work.
- B. Submit literature for the Engineer's approval on:
 1. Forms, if fabricated off construction site
 2. Metal forms
 3. Form ties or through-bolts
 4. Form coatings and Release Agent.

1.4 JOB CONDITIONS

- A. Falsework and vertical shoring:
 1. Design, construction, inspection, and removal of falsework and vertical shoring shall be in full conformance with the provisions of Section 1717 of the Construction Safety Orders, Title 8, California Code of Regulations.
 2. All falsework or vertical shoring installations where the height of the falsework or vertical shoring, as measured from the top of the sills to the soffit of the superstructure, exceeds 14 feet, or where individual horizontal span lengths exceed 16 feet shall be approved and signed by a civil engineer, registered in the State of California.
 3. A copy of the approved falsework plan or shoring layout shall be available on the job site at all times.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Plywood for forms shall be Plyform Class I, B-B EXT-APA, conforming to the specifications of the U. S. Department of Commerce Voluntary Product Standard PS-1 requirements.
- B. Metal forms may be used on approval of the Engineer.

- C. Alternate form materials, such as hard bond fiberglass or steel, may be used to provide an F3 finish (See Section 03 35 00 – Concrete Finishing).
- D. Form ties:
1. Form ties shall be of sufficient strength and number to prevent spreading of the forms during the placement of concrete and to permit ready removal of the forms without spalling or damaging the concrete.
 2. Space ties at uniform intervals across surface; align in horizontal and vertical directions.
 3. Do not use wire ties or wood spreaders of any type.
 4. Provide form ties of such design that when forms are removed, they leave no metal or other material within 1-1/2 inches of the surface of the concrete.
 5. No form-tying device or part thereof other than metal shall be left imbedded in the concrete.
 6. Cone-snap ties:
 - a. Cone-snap ties shall form a cone shaped depression in the concrete with a minimum diameter of 1 inch at the surface of the concrete and 1-1/2 inches deep and all such fasteners shall be such as to leave holes of regular shape.
 - b. Provide neoprene Waterseal washer that is located near the center of the concrete.
 7. Taper ties:
 - a. Neoprene plugs for taper tie holes: Size so that after they are driven, plugs re located in center third of wall thickness.
- E. Form Release Agent:
1. When required to prevent bond, forms shall be treated with an approved compound which is not deleterious to concrete, and which will not cause discoloration of the finished surface.
 2. Use a resin base form release agent on forms for concrete to be painted.

- F. Falsework and shoring:
1. Falsework and forms shall be constructed to produce in the finished work the lines and grades indicated on the drawings.
 - a. Suitable jacks, wedges, or camber strips shall be used in connection with falsework to set the forms to the required grade or camber and to take up any settlement in the formwork either before or during the placing of concrete.
 - b. Falsework shall be formed upon solid footing safe against undermining and protected from softening.
 2. Manufactured shores of adjustable type shall not be used if wear, damage, or defects make them incapable of supporting the loads for which they were designed.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Form all cast-in-place concrete unless specified otherwise.
- B. Surfaces of all forms in contact with concrete shall be clean, rigid, tight, and smooth unless otherwise specified.
- C. Reusable forms shall be of such a type that they can be entirely removed and remain watertight upon reuse.

3.2 CONSTRUCTION OF FORMS

- A. Form panels that are attached directly to the studding or joists, shall be not less than 5/8-inch thick, and the studding or joists shall be placed not more than 12 inches center-to-center.
- B. Form panels less than 5/8-inch thick, otherwise conforming to the requirements specified in this section, may be used with a continuous backing of surfaced material 3/4-inch thick.
- C. Form panels more than 5/8-inch thick attached to studding or joists spaced at more than 12 inches center-to-center may be used, provided that deflection of the panel between studding or joists does not exceed that of a 5/8-inch panel attached to studding or joists spaced at 12 inches center-to-center.
- D. Suitable and effective means shall be provided on all forms for holding adjacent edges and ends of panels and sections tightly together and in accurate alignment so as to prevent the formation of ridges, fins, offsets, or similar defects in the finished concrete exceeding the allowable irregularities for the formed finishes specified.

- E. Exposed edges on the outside and inside of structures shall be chamfered with triangular fillets 3/4" by 3/4", unless otherwise noted on the drawings or ordered by the Engineer.
- F. Provide for temporary openings for cleaning out, observation, pouring and vibration of concrete.
- G. Where forms for continuous surfaces are placed in successive units, the forms shall fit tightly over the completed surface so as to prevent leakage of mortar from the concrete and to maintain accurate alignment of the surface.
- H. Provide tight seams, or seal with tape, to be mortar-tight.
- I. Reset forms shall overlap the hardened concrete with sufficient tie bolts so as to prevent loss of mortar or spreading of the forms when concrete placement is resumed.
- J. Set and maintain concrete forms so as to ensure that the completed work is within the tolerances specified herein.
- K. Keep the deflection of wall or slab form sheathing or framing for beams within 1/270 of the span. Consider camber in designing the supports of beams and slabs.
- L. Forms for outside surfaces shall be constructed with stiff wales at right angles to the stud, and all form ties shall extend through and be fastened to wales.
- M. Chamfers: 3/4-inch at all exposed outside comers, including the top edges of all walls, machinery bases and curbs. Use mill run chamfer strips surfaced all sides. Provide rounded top edges of sidewalks, walkways and where directed.
- N. Form ties:
 - 1. Cone-snap ties: Tie forms together at not more than 2-foot centers vertically and horizontally. After forms are removed, fill tie holes as follows:
 - a. Remove form ties from surfaces.
 - b. Roughen cone shaped tie holes by abrasive blasting before repair.
 - c. Fill tie holes with dry-pack mortar as specified in Section 03 30 00.
 - 2. Taper ties:
 - a. After forms and taper ties are removed from wall, plug tie holes with neoprene plug as follows:
 - 1) Clean and roughen tie holes.

- 2) Drive neoprene plug into each of taper tie holes with steel rod. Final location of neoprene plug shall be in center third of wall thickness. Bond neoprene plug to concrete with epoxy.
 - 3) Locate steel rod in cylindrical recess during driving. At no time are plugs to be driven on flat area outside cylindrical recess.
- b. After installing plugs in tie holes, Dry-pack of taper tie holes:
- 1) Coat tie hole surface with epoxy bonding agent and fill with dry-pack mortar as specified in Section 03 30 00.
 - a) Place dry-pack mortar in holes in layers with thickness not exceeding tie hole diameter and heavily compact each layer.
 - b) Dry-pack the outside of the hole no earlier than 7 days after the inside of the hole has been dry-packed.

3.3 ALLOWABLE VARIATIONS FOR FORMED SURFACES

- A. General: Set and maintain concrete forms to ensure that, after removal of the forms and prior to patching and finishing, no portion of the concrete work will exceed any of the tolerances. Measure variations in floor or roof levels before removal of supporting shoring. Accept responsibility for variations due to deflections resulting from concrete quality or curing other than that specified. The specified variation for one element of the structure will not be applicable when it will permit another element of the structure to exceed its allowable variation.
- B. Tolerances: ACI 301 and the relevant subsections of ACI 117 and as noted below:
- C. Variations in Size or Thickness:
1. Footings:
 - a. Length and width: $\pm 1/2$ inch
 - b. Reduction in thickness: 5%
 2. Slabs and walls:
 - a. Thickness of 6 inches or less: 0 inch
 - b. Thickness of more than 6 inches: $\pm 1/4$ inch

3.4 REMOVAL OF FORMS

- A. General: Remove without damage to the concrete and with complete safety of the structure. Ensure that the concrete has hardened sufficiently, and the members have attained sufficient strength to safely support the imposed loads.
- B. Forms for columns, walls, sides of beams and other parts not supporting the weight of the concrete may be removed only after the concrete has sufficient strength to resist damage from deflection, misalignment, cracking, spalling, and form removal operations, particularly when form ties will be bent by the removal operations, but not less than 3 days after concrete has been placed.
- C. Falsework and forms supporting cast-in-place concrete beams, slabs, or other members subject to bending stresses shall not be removed or released less than 21 days after the concrete has been placed or until the concrete has reached the specified minimum compressive strength, whichever comes first.
- D. Cold Weather: Engineer may increase the minimum form removal times if the temperature is 40°F or lower.

END OF SECTION

SECTION 03 20 00

CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Concrete reinforcement.
- B. Related Sections:
 - 1. Section 03 30 00 - Cast-In-Place Concrete.
 - 2. Section 03 01 30.62 – Concrete Repair.
 - 3. Section 05 50 10 – Anchor Systems.

1.2 REFERENCES

- A. American Concrete Institute (ACI):

| Reference | Title |
|-----------|---|
| ACI 315 | Details and Detailing of Concrete Reinforcement. |
| ACI 318 | Building Code Requirements for Structural Concrete. |

- B. American Society for Testing and Materials (ASTM):

| Reference | Title |
|-----------|---|
| ASTM A615 | Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement. |

1.3 SUBMITTALS

- A. Submit in accordance with Section 01 33 00 – Submittals.
- B. Product Data:
 - 1. Bar supports and chairs.
 - 2. Adhesive doweling system, including evaluation reports by ICC Evaluations Services, Inc. see Section 05 50 10.
- C. Shop Drawings:
 - 1. Shop and placement drawings for all reinforced concrete structures to be reviewed by Engineer, which show:
 - a. All construction and expansion joints.

- b. Reinforcement detailed in conformance with ACI 315.
 - c. Assembly diagrams, including bar lap and splice locations and mechanical splice layout.
 - d. Accessories and inserts layout.
 - e. Support bars and details of bar supports including type, size, and pacing.
 - f. Marking for each reinforcement item.
2. Changes to Reinforcing Steel Contract Drawing Requirements:
 - a. Indicate in separate letter submitted with shop drawings any changes of requirements indicated on Drawings for reinforcing steel.
 - b. Such changes will not be acceptable unless Engineer has accepted such changes in writing.
 3. Review of shop drawings by Engineer will be limited to general compliance with Contract Documents.

1.4 QUALITY ASSURANCE

- A. Do not fabricate reinforcement until shop and placement drawings have been reviewed by Engineer. Contractor shall provide a concrete placing schedule to Engineer, before setting reinforcement, which clearly indicates the order of concrete placement for each structure.
- B. Replace all reinforcement with bends and kinks not shown on fabrication shop drawings. Remove from job site all such reinforcement and replace with new fabricated steel. Field bending of reinforcement at the work site is prohibited.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver reinforcement and accessories to work site with items of same size and shape fastened in bundle clearly marked with securely wired-on metal identification tags giving size and mark.
- B. Store reinforcement and accessories off ground on platform or skid supports and protect with water resistant covers from snow, rain and ground splatter.
- C. Protect reinforcement from rusting, deforming, bending, kinking and other damages.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Reinforcing Bars:

1. Provide newly rolled deformed billet-steel reinforcing bars conforming to ASTM A615, Grade 60.
2. Provide newly rolled deformed billet-steel reinforcing bars conforming to ASTM A706, Grade 60 as noted in Drawings and where welding of reinforcing bars is required.
3. Welded wire fabric conforming to ASTM A185.
4. Mill bend reinforcing bars cold to dimensions indicated and conforming to requirements of ACI 315.

B. Reinforcing Bar Supports:

1. Reinforcement Support Chairs:

- a. Provide hot-dip galvanized steel with plastic tips at surfaces which will be exposed to view unless otherwise indicated on Drawings.
- b. Use Stainless Steel when indicated on Drawings.
- c. Use precast concrete block supports with embedded wire ties or dowels for placement on grade or on membranes. Cast the blocks with concrete equal in strength, cement type and aggregate to the parent concrete.

C. Tie Wires:

1. Provide 16 gage minimum mild steel or annealed iron tie wire.

D. Adhesive:

1. See Section 05 50 10 paragraph 2.1 B.

2.2 FABRICATION

- A. Splice, development and embedment lengths as indicated on Drawings.
- B. Perform cutting and bending of reinforcing bars before shipment to the site. Bend bars cold and in a manner that will not injure the material.
- C. Detail and fabricate the reinforcing bars to provide specified cover to outer edge of steel and other installed items.

- D. Provide deformed reinforcing bar dowels at all construction joints, unless otherwise noted.
- E. Provide same dowel size and spacing as the reinforcing to which they are spliced, unless otherwise noted.
- F. After shop drawings are reviewed by Engineer, fabricate each unit of reinforcement to conform to the type, shape, and size indicated on the fabrication shop drawings.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Before placing in form, clean all reinforcement and accessories of mortar, oil, dirt, loose mill scale, loose or thick rust, and coatings of any character that would destroy or reduce the bond with the concrete.
- B. Do not allow form coatings, release agents, bond breaker, or curing compound to contact reinforcement.

3.2 INSTALLATION

- A. Place reinforcing bars to tolerances given in ACI 318 and as specified, and hold in position using tie wire with ends pointed away from forms.
- B. Bars may be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items, but not so as to impair design strengths of the member. If bars are moved more than two bar diameters, submit resulting arrangement of bars for review and acceptance by the Engineer. Place required number of bars.
- C. Set and tie all dowels before placing concrete. Setting dowels into wet concrete is prohibited.
- D. Use chairs, bolsters and spacers to hold reinforcing bars in place, of sufficient strength to resist crushing under load in accordance with ACI 315. Metal chairs, ferrous clips, nails, etc. which extend to the surfaces of the concrete, and stones, brick chips, wood block supports not to be used.
- E. Use precast concrete bar support blocks for foundation mats, base slabs, footings, pile caps, grade beams, and slabs on grade.
- F. Placing bars on layers of fresh concrete as the work progresses, and adjusting bars during the placement of concrete is prohibited.
- G. Place bar laps in contact and tie securely, or space transversely apart to permit embedment of entire surface of each bar in concrete. Length of laps for bars to conform with requirements of ACI 318, unless otherwise indicated.

- H. Stagger lap splices in adjacent parallel bars whenever possible.
- I. Tie a minimum of one-half, 50 percent, of all intersecting bars in foundation mats, base slabs, footings, pile caps, slabs on grade and elevated slabs.
- J. Do not splice reinforcement steel in foundation mats, base slabs, beams, girders, slabs and walls at points of maximum stress unless otherwise indicated.
- K. Provide continuous reinforcement through construction joints unless otherwise detailed or noted.
- L. Do not use continuous reinforcement or other fixed metal items through expansion joints. Provide two-inch reinforcement clearance from each face of expansion joint.
- M. Do not field bend bars, including bars partially embedded in concrete, unless otherwise indicated. Do not straighten or bend bars in manner injurious to steel or concrete.
- N. Do not place bars that have kinks and bends other than shown on Engineer reviewed shop drawings. Remove all such damaged bars from job site and replace at no additional cost to the District.
- O. Do not use heat to bend or straighten reinforcing steel.
- P. Immediately paint all reinforcement which is to be exposed for more than 90 days with coat of neat cement grout to prevent rust formation.
- Q. Where bars are to be lapped spliced at joints in concrete, ensure bars project from concrete first placed, minimum length equal to lap splice length indicated on Drawings.
- R. Adhesive Dowels: See Section 05 50 10

3.3 FIELD QUALITY CONTROL

- A. Inspect all reinforcement installation. Give Engineer 48 hours advance notice for inspection before concrete placement.
- B. Special Inspections and Testing of Dowels: See Section 05 50 10 paragraph 3.3.

END OF SECTION

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:

1. All cast-in-place concrete required including structural, site work, and base pads for mechanical and electrical equipment.
2. Concrete shoring, formwork, patching, and grouting.
3. Concrete curing.

B. Related Sections:

1. Section 03 01 30.61 – Resurfacing of Cast-in-Place Concrete.
2. Section 03 01 30.62 – Concrete Repair.
3. Section 03 20 00 – Concrete Reinforcement.
4. Section 03 35 00 – Concrete Finishing.

1.2 REFERENCES

A. American Concrete Institute (ACI):

| Reference | Title |
|-----------|--|
| ACI 117 | Standard Tolerances for Concrete Construction and Materials |
| ACI 211.1 | Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete |
| ACI 301 | Specifications for Structural Concrete |
| ACI 347R | Guide to Formwork for Concrete |

B. American Society for Testing and Materials (ASTM) Standard Test Method:

| Reference | Title |
|------------|---|
| ASTM C29 | Bulk Density (“Unit Weight”) and Voids of Aggregates. |
| ASTM C31 | Making and Curing Concrete Test Specimens in the Field |
| ASTM C33 | Concrete Aggregates |
| ASTM C39 | Compressive Strength of Cylindrical Concrete Specimens |
| ASTM C94 | Standard Specification for Ready-Mixed Concrete |
| ASTM C136 | Sieve Analysis of Fine and Coarse Aggregates |
| ASTM C150 | Standard Specification for Portland Cement |
| ASTM C260 | Air-Entraining Admixtures for Concrete |
| ASTM C494 | Chemical Admixtures for Concrete |
| ASTM C618 | Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete |
| ASTM C1240 | Silica Fume Used in Cementitious Mixtures |

1.3 SUBMITTALS

- A. Submit in accordance with Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. Concrete mix designs. See 1.4 C. and D., and 2.5.
 - 2. Portland Cement: Manufacturer's certificate of compliance with ASTM C 150 and standard physical and chemical analysis.
 - 3. Pozzolan: Furnish with each shipment a certificate with test data showing compliance with ASTM C 618.
 - 4. High Reactivity Metakaolin
 - 5. Silica Fume
 - 6. Aggregates: Furnish sieve analysis, physical properties, and deleterious substance for both fine and coarse aggregates proposed for the work.
 - 7. Coarse and fine aggregates: If requested, submit for the Engineer's approval, two weeks in advance of the concrete work, a representative sample of each size of fine and coarse aggregate to be used. Size of each sample shall be not less than 50 pounds.
 - 8. Admixtures:
 - a. Manufacturer's test data showing performance of product in concrete as to air content, water reduction, retardation, and effect on concrete strength at various ages, for concrete temperatures ranging 50 degrees F to 90 degrees F.
 - b. If requested, submit 10-ounce sample of each product proposed for use in concrete mix.
 - 9. Bonding Agents: Product information and the manufacturer's recommendations for the product application.
 - 10. Ready-mix plant certification.
 - a. Concrete Mix test results.
 - 11. Formwork products.
 - a. Forms, if fabricated off construction site.
 - b. Form ties or through-bolts.
 - c. Form coatings.

12. Curing materials and curing program.

C. Shop Drawings:

1. Construction and control joints layout.
2. Sequence of concrete pours.

D. Samples of materials required for testing under this section shall be submitted to the District Materials Testing Laboratory, 1100 21st Street, Oakland. A minimum of one day in advance, make an appointment for the sample delivery by calling the laboratory at (510) 287-1990 between 8:00 a.m. and 10:00 a.m.

1. Complete a submittal log for all Concrete Data.

1.4 QUALITY ASSURANCE

A. Codes and Standards:

1. Comply with all pertinent recommendations and applicable requirements of ACI 301 and ACI 350.
2. State of California Department of Transportation: Standard Specifications, latest edition (CSS).

B. Concrete Products and Materials Tests: Certified by independent commercial testing laboratory employed by the Contractor. Submit certification on cementitious products and aggregates performed within the past 12 months.

C. Concrete Mix Designs: By independent commercial testing laboratory employed by the Contractor and complying with ASTM C1077. The design submittal shall be signed by a California Registered Civil Engineer and approved by Engineer.

D. Concrete Mix Test Results:

1. Submit result statistics of satisfactory mix designs from trial mix reports or, if available, from prior projects performed within past 2 years.
2. Allow adequate time for review of submittals and adjustments to comply with the Specifications.

E. Concrete Tests, as Placed:

1. The District's Testing Agency will inspect and perform strength tests on concrete cylinder samples in accordance with ASTM C 39.
2. Strength tests on core samples (if needed) will be performed in accordance with ASTM C 42.

3. Concrete Samples:
 - a. Contractor shall provide all labor and equipment required to make the concrete samples, store them on site during initial cure, and deliver concrete cylinder samples to District Materials Testing Laboratory located at the address listed in Article 1.3. The District will provide the molds for making concrete cylinders.
 - b. Samples shall be made in accordance with ASTM C 31 and ASTM C 172. Provide site storage and initial cure, 24 hours minimum.
 - c. Unless specified elsewhere, a set of six standard 6-inch x 12-inch concrete cylinders shall be cast for each mix type placed, each day placed, or each 50 cubic yards placed or fraction thereof.
 - d. Label samples using a nomenclature provided by the Engineer.
 - e. Compressive strength: By District Materials Testing Laboratory in accordance with ASTM C39 (Typically, two cylinders at age of 7 days, two at 28 days).
4. Slump: By Contractor using slump cone in accordance with ASTM C143 and observed by the Engineer.
 - a. Test each sample used for strength tests, at the beginning of each placement, as often as necessary to keep slump within specified range required by the Concrete Mix Design Table.
 - b. Results outside the limits indicate possible cause for rejection of concrete. The Engineer shall be the sole judge.
5. Air Content: Contractor shall test for percent of entrained air on concrete samples used for strength tests immediately after discharge from mixer per ASTM C231. Furnish calibrated equipment required to perform the test. See 2.5 C. for required air content.

F. Additional Core Samples and Tests:

1. If in the opinion of Engineer, results of tests on concrete cylinders indicate the possibility of substandard concrete in the structure, cored samples may be required to be taken from the concrete. The contractor shall provide all labor and equipment required to obtain the core samples.
 - a. The Contractor shall take 3 cores, in accordance with ASTM C42, from the area representing the cylinders in which the strength is in question and deliver them to District Materials Testing Laboratory for strength tests.

2. If, in the opinion of Engineer, the results of the core tests indicate that concrete has been placed does not meet this specification, remove and replace the defective concrete at no additional cost to District.
3. The Contractor may be reimbursed per Document 00 72 00 Article 7 for the coring cost if test results on the core samples indicate that the placed concrete meets the specification, and if it can be demonstrated that the original concrete cylinder samples were properly obtained.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Cementitious Materials: If required at site, store immediately after delivery in a dry, weather tight, properly ventilated structure, with adequate provisions for prevention of moisture absorption and overheating of the cement.
- B. Aggregates: If required at site, store in piles which afford good drainage and which are protected to prevent the inclusion of foreign material. Stockpile the various sizes or gradations of aggregates separately.
- C. Lumber: Store all lumber, including plywood for forms, to prevent direct contact with the ground. Protect the stored lumber from the elements by a suitable covering, such as polyethylene film or waterproof building paper, suitably held in place.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Obtain materials from an established and experienced manufacturer or supplier. Provide new materials of first-class ingredients guaranteed to perform the service required.

2.2 CONCRETE MATERIALS

- A. Cementitious Materials:
 1. General: Use only one brand of each cementitious material. The color shall not significantly alter the typical grey concrete color.
 2. Portland Cement: ASTM C150, Type II, containing total alkali less than 0.6 percent.
 3. Fly Ash: ASTM C618, Class F.
 4. Silica Fume: ASTM C1240.

5. High Reactivity Metakaolin: High reactivity metakaolin shall be in accordance with ASTM C618, Class N, including all optional requirements, with the exception and additions as follows:

| High Reactivity Metakaolin Requirements | |
|--|--------------|
| Item | Requirements |
| Loss on ignition | 1.0% maximum |
| SO ₃ content | 1.0% maximum |
| Moisture content | 1.0% maximum |
| Fitness (retained #325) | 1.0% maximum |
| SiO ₂ +Al ₂ O ₃ +Fe ₂ O ₃ | 95% minimum |
| Strength activity index | 85% minimum |

B. Aggregates:

1. General: ASTM C33

- a. Provide free from organic materials, chlorides, waste products, clay balls, shale, and mica and thoroughly washed before use.
- b. Maximum size shall be 1-inch for all concrete on the project. For thin sections, such as slabs or walls 10 inches thick or less, or for sections that require special placement due to shape, form, or congestion of reinforcing, provide ¾-inch maximum size.
- c. Provide aggregates that do not deleteriously react with the alkalis in the cement.
- d. Grading: Submit results of sieve analysis.
- e. Reactivity: ASTM C289. Submit graphical data showing compliance.

2. Coarse Aggregates:

- a. Provide clean, hard, durable gravel, crushed gravel, crushed rock, or combinations.
- b. Deleterious substances: Submit compliance with ASTM C33, Table 3 and as follows:
 - 1) Cleanness: CALTRANS Test 227. For three tests, not less than 70, with an average greater than 75.

- c. Do not use aggregate containing more than 10% of inferior materials, flat or elongated particles, cracked or laminated rock, or rock than can be readily broken after immersion in water for one hour.
- d. When tested in accordance with ASTM C136, coarse aggregate shall conform to the following limits:

| Sieve Size | Percentage Passing | |
|------------|---------------------------------|-----------|
| | Primary Aggregate Nominal Sizes | |
| | 1" x #4 | 3/4" x #4 |
| 1-1/2" | 100 | - |
| 1" | 88-100 | 100 |
| 3/4" | 65-90 | 90-100 |
| 3/8" | 15-35 | 15-40 |
| No. 4 | 0-16 | 0-5 |

3. Fine Aggregate:

- a. Provide natural sand or a combination of natural and manufactured sand, of siliceous, granite or igneous origin, hard and durable.
- b. Deleterious substances: Submit compliance with ASTM C33 Table 1 and as follows:
 - 1) Sand equivalent: ASTM D2419 or CALTRANS Test 217. For three tests not less than 70, with an average greater than 75.
- c. When tested in accordance with ASTM C 136, fine aggregate shall conform to the following limits:

| Sieve Number | Percentage Passing |
|--------------|--------------------|
| 4 | 95-100 |
| 8 | 65-95 |
| 16 | 45-85 |
| 30 | 25-55 |
| 50 | 10-35 |
| 100 | 2-12 |
| 200 | 0-8 |

2.3 WATER

- A. Provide water for washing aggregates, for mixing concrete, for patching grout and for curing: Potable
- B. Engineer may require tests of the water should there be a question of the quality. Costs of such tests would be borne by District.

2.4 ADMIXTURES

- A. Air Entraining: ASTM C260.
- B. Water Reducing: ASTM C494, Type A or D.
- C. No admixture containing any chloride ions is acceptable.
- D. Pigments for integrally colored concrete: ASTM C979, for synthetic or natural oxides.

2.5 CONCRETE MIX DESIGN

- A. General:
 - 1. Employ an independent commercial testing laboratory complying with ASTM C1077 and approved by the Engineer to design all concrete mixes and carry out all necessary testing that is not by the District Materials Testing Laboratory.
 - 2. If the testing laboratory has satisfactory mix designs available from prior projects, submit test record statistics to demonstrate compliance with the requirements of this Section and ACI 301 (latest edition).
 - 3. If new mix designs are required, prepare a range of trial batches for each design and submit the mixes that demonstrate satisfactory test results.
 - 4. Allow for the variability of concrete strength from test to test by increasing the required average compressive strength over the specified strength as specified in ACI 318 (latest edition).
 - 5. Design the mixes far enough ahead of concrete placement to allow completion of trial batch testing and submittal of the test results and mix design to the Engineer for review.
 - 6. Take sole responsibility for selection of laboratory, submittal of materials to laboratories in time for all tests, and overall timing of all aspects of testing program, including submittals.
 - 7. Prepare mix designs for concrete placement by the batch process and/or by pumping, as required, and state the process on the design submittal.
 - 8. Allow for the hot or cold weather and the time required to transport the concrete from the mixer to the site and to place within the forms. If accelerating or retarding admixtures are required for only a proportion of the concrete placements, submit test results that include the full range of options.

9. Do not exceed the water-cementitious material ratios. Vary the water-reducing admixtures to accomplish an increase in slump or workability time.
10. Proportion cementations materials, aggregates, and water by weight.
11. Check periodically the weight of moisture contained within the stockpiled aggregates. Compensate for this water when proportioning the concrete mix and adjust when change occurs.
12. Do not use chlorides in any concrete mix. Total chloride ion content of the concrete mix, including all ingredients, shall not exceed CBC limits.

B. Mixes:

1. Classes: Meeting requirements in Table A. All structural concrete shall be Class A unless otherwise noted.

| Class | Uses | Minimum Compressive Strength at 28 days, psi | Max. Water Cement Ratio (w/cm) |
|-------|--|--|--------------------------------|
| A | Equipment pads | 4,500 | 0.40 |
| B | Non-structural concrete and duct banks | 3,000 | 0.50 |
| C | | 1,500 | 0.76 |

2. Limit supplementary cementitious materials measured as a percent of weight of total cementitious materials in mix design, as follows:
 - a. Fly Ash and other Pozzolans: 15 percent
 - b. High reactivity metakaolin: 10 percent
 - c. Combined Fly Ash and other Pozzolans, and Metakaolin: 25 percent, with fly ash and other pozzolans not exceeding 15 percent, and metakaolin not exceeding 10 percent
3. Consistency: Carefully mix concrete to produce homogeneous, fluid material capable of being worked into constricted areas of forms, corners, and around embedded items, without segregation of free water bleeding. Provide slump ranges in Table B. Measure consistency by ASTM C143.

| TABLE B | | |
|---|---------------|---------|
| Portion of Structure | Slump, inches | |
| | Maximum | Minimum |
| Equipment pads, Non-structural concrete and ductbanks | 5 | 3 |

Provide additional slump if needed for pumped concrete to provide slump per Table B at discharge of pump line.

C. Mix Test Requirements:

1. Compression: See 1.4 E.
2. Slump: ASTM C143. Slump range as shown in Table B.
3. Air Content : ASTM C231. $4 \pm 1 \frac{1}{2}\%$.
 - a. Prisms shall be moist cured for 7 days prior to 28-day drying period.
 - b. Comparator reading at end of 7-day moist cure shall be used as initial length in length change calculation.
 - c. Reported results shall be average of three prisms.
 - d. If shrinkage of specimen departs from average of that test age by more 0.004 percent, disregard results obtained from that specimen.
 - e. Unless otherwise specified, results at end of 28-day drying period shall not exceed 0.040 percent if 3-inch prisms are used or exceed 0.038 percent if 4-inch prisms are used. Aggregate will be rejected if test values exceed these limits.
4. After approval of the mix design, no variations of the constituents are permitted during the project without prior approval by Engineer.

D. Use Class A concrete for all concrete unless indicated otherwise. Use Class B concrete when indicated and when approved by the Engineer. Use Class C concrete whenever low-strength concrete is permitted by Engineer for concrete under foundations.

2.6 READY-MIX CONCRETE

- A. Supply concrete for the project using truck mixers and a ready-mix plant certified by the National Ready-Mix Concrete Association. Submit certification.
- B. Alternatively, qualify the supplier according to ASTM C94 Sections 8 through 11, inclusive.

2.7 GROUT

- A. Spreading over surfaces of construction joints:
 1. One part of cement, two parts of sand (by weight), and only sufficient water to give required consistency for spreading.
 2. Mix with no more water used than that allowed by water-cement ratio specified for concrete

3. Minimum compressive strength at 28 days shall be 4,500 psi.

B. Dry Pack:

1. One part of cement, two parts of sand (by weight), and only sufficient water so that resulting the grout will crumble to touch after being formed into ball by hand.

2.8 CEMENT MORTAR – SEE SECTION 03 01 30.62

2.9 NON-SHRINK GROUT – SEE SECTION 03 62 00

2.10 CONCRETE BONDING ADHESIVE

A. Two-component liquid epoxy designed for bonding fresh concrete to existing concrete.

B. Approved products:

1. Concessive Liquid (LPL), manufactured by Master Builders and available from Muller Construction Supply, San Francisco, CA (415) 282-8001.

2. Sikadur 32, manufactured by Sika Corporation and available from D. M. Figley Co., Menlo Park, CA, (800) 292-9919.

3. Or equal.

2.11 FORMS

A. Provide forms, and architectural form liners where required, for exposed concrete surfaces with a clean, smooth plywood or metal face. Exposed concrete surfaces include beams, columns, slabs, walls and other surfaces of tank and channel walls.

B. Unless otherwise indicated on drawings provide forms for vertical surfaces of foundations. In no case shall vertical surfaces of concrete be cast against earth.

2.12 FORM TIES

A. Provide commercially manufactured steel rods or through-bolts, not wire, capable of withstanding applied pressures.

B. Furnish ties adjustable in length or of proper fixed length, with no metal closer than 1-1/2 inch to the finished concrete surface. Leave no holes larger than 1-inch-diameter at the surface. Use a plastic cone spacer at each end of the form tie to allow a full 1-1/2-inch break back.

C. In walls resisting water or earth pressure, provide ties with waterstop washers of diameter 3/4-inch greater than the rod, bonded to rods at the wall centerline, or with other approved water seal devices. Alternately, furnish through-bolts with a

manufactured neoprene or polyurethane tapered plug to be installed at the wall centerline.

2.13 FORM COATING COMPOUNDS

- A. Do not stain or impart any material or residue to the concrete surface that will be detrimental or incompatible with any specified paint or coating system to be applied later.

2.14 CURING MATERIALS

- A. Curing Compound: Consists of liquid which, when applied to fresh concrete by means of spray gun, will form impervious membrane over exposed surface of concrete with compound not preventing future bond of floor covering, and concrete floor treatment. Use Type I-D compound with red fugitive dye, Class B, in conformance with ASTM C309.
 - 1. Manufacturers: One of the following or equal:
 - a. BASF Construction Chemicals, LLC, Shakopee, MN, Kure-N-Seal.
 - b. Euclid Chemical Company, Cleveland, Ohio, KUREZ DR.
- B. Waterproof Curing Sheet: Waterproof paper or white opaque polyethylene film conforming to ASTM C171.
- C. Cloth, Burlap, Jute or Kenaf: CCC-C-467C.
- D. Vapor Barrier: Polyethylene sheet, 6 mils thick conforming to ASTM E154 or polyethylene-coated asphalt-saturated reinforced kraft paper.

2.15 SOURCE QUALITY CONTROL

- A. Forms: Verify that components pre-assembled offsite are satisfactory for the purpose. Verify, that designs, products, and samples have been submitted for Product Review.
- B. Concrete:
 - 1. Verify that ready-mix batch plant delivery tickets contain all product information necessary for acceptance of the concrete delivered to site.
 - 2. Verify that the mixing and trucking equipment have adequate capacity to deliver the concrete batches to site on time, thoroughly mixed and discharge without segregation.

PART 3 - EXECUTION

3.1 PROPORTIONING CONCRETE MATERIALS

- A. Place no concrete prior to approval of submittals for reinforcing steel, materials specified in this Section and the mix proposed. Unfavorable results of actual pours may require a redesign of mixes.
- B. Make no substitutions to the constituents tested in the design of concrete mixes without approval of the revised mix and the new test results.

3.2 BATCHING AND MIXING CONCRETE MATERIALS

- A. Ready or Transit Mixed Concrete:
 - 1. Deliver completely mixed to the project site.
 - 2. Do not add mixing water during hauling. Add water after delivery only when agreed by the Engineer. Should water be added, revolve the mixing drum not less than 30 revolutions at mixing speed after adding and before commencing discharge.
 - 3. Deliver each load at the job site accompanied by a ticket showing mix design number, volume of concrete, and the weight of cement in pounds and the total weight of each ingredient in pounds. Also show the time at which the materials were batched and the reading of the revolution counter at the time the truck mixer was charged.
 - 4. No re-tempering of partially hardened material is permitted. Do not use partially hardened concrete in the work.
- B. Batching in Adverse Weather:
 - 1. Cold Weather: When the atmospheric temperature is below 40°F, or is likely to fall below 40°F during the 24-hour period after placing, heat the materials before mixing, so that the temperature of the mix when deposited shall be between 65° and 80°F. Do not heat the mixing water or the cement over 160°F. Remove lumps of frozen material and ice from the aggregates before they are placed in the mixer.
 - 2. Hot Weather: When temperatures are above 90°F, reduce the temperature of the concrete mix by using iced mixing water, and protecting aggregates and cement from direct rays of the sun. Do not place concrete exceeding 80°F.
 - 3. Should the provisions have noted in 1. and 2. above not be possible or practicable, postpone the batching until favorable weather conditions prevail.

3.3 FORMS

A. General:

1. Take responsibility for adequacy of the form, bracing, and shoring. Satisfy ACI 347R.
2. Form all concrete unless specified otherwise.
3. Construct forms conforming to the shape, line and grade specified.
4. Provide tight seams, or seal with tape, to be mortar-tight.
5. Brace and shore all forms properly to ensure stability against pressure from any source, without failure of any component part.
6. Keep the deflection of wall or slab form sheathing or framing for beams within 1/270 of the span. Consider camber in designing the supports of beams and slabs.
7. If inadequate support is provided by the forms, remove all placed concrete and replace, as directed.
8. Provide for temporary openings for cleaning out, observation, pouring and vibration of concrete.

B. Chamfers: 3/4-inch at all exposed outside comers, including the top edges of all walls, machinery bases and curbs. Use mill run chamfer strips surfaced all sides. Provide rounded top edges of sidewalks, walkways and where directed.

C. Formed Surfaces:

1. Ensure that the reinforcement has been approved before closing up the wall forms.
2. Provide exposed, unpainted concrete surfaces that are uniform in appearance and color. Apply non-staining mineral oil, form coating or form release compound before placing the forms. Remove any excess coating with cloths. Scrape and clean any reused forms before coating again.
3. Provide flush fitting caps over any unused form tie holes.
4. Do not use mineral oil on formed surfaces that are to be painted, coated, or bonded to other concrete.

D. Form Ties and Through-Bolts:

1. Provide sufficient number and strength to prevent spreading of forms while placing concrete.

2. Remove the removable portion immediately after stripping the forms. Avoid spalling the exposed concrete surfaces.
 3. Locate tapered ties, if used, with the larger diameter on the water side of the form.
 4. Provide a separate support system for the curtains of reinforcing, with a minimum 1-inch clearance between rebar and form ties or bolts.
- E. Construction Joints:
1. Provide forms at ends of the first concrete pour. Ensure the end forms of walls are removable without releasing the side forms. Provide seals around reinforcement to prevent mortar leaks.
 2. Overlap the hardened concrete of the first pour with forms for the second pour. Brace the ends of the forms against the hardened concrete to prevent joint offsets and mortar leakage. Align any exterior features required on the finished surface.

3.4 ALLOWABLE VARIATIONS FOR FORMED SURFACES

- A. General: Set and maintain concrete forms to ensure that, after removal of the forms and prior to patching and finishing, no portion of the concrete work will exceed any of the tolerances. Measure variations in floor or roof levels before removal of supporting shoring. Accept responsibility for variations due to deflections resulting from concrete quality or curing other than that specified. The specified variation for one element of the structure will not be applicable when it will permit another element of the structure to exceed its allowable variation.
- B. Tolerances: ACI 301 and the relevant subsections of ACI 117 and as noted below:
- C. Variations in Size or Thickness:
1. Equipment Pads:
 - a. Thickness of 1'6 inches or less: 0 inch
 - b. Thickness of more than 1'-6 inches $\pm 1/8$ inch

3.5 REMOVAL OF FORMS

- A. General: Remove without damage to the concrete and with complete safety of the structure. Ensure that the concrete has hardened sufficiently, and the members have attained sufficient strength to safely support the imposed loads.
- B. Removal Time: Minimum duration after completion of concrete placement:
1. Equipment Pads 24 hours

- C. Cold Weather: Engineer may increase the minimum form removal times if the temperature is 40°F or lower.
- D. Re-shoring: Submit for approval, any requirement for accelerated partial stripping and re-shoring of forms that may be necessary to maintain the construction program.

3.6 REUSE OF FORMS

- A. Between concrete placements, inspect all form surfaces and repair to uniform texture for all concrete surfaces to be exposed. Fill all unused holes, cracks and defects.

3.7 PLACING CONCRETE AND GROUT

A. Preliminary Work:

1. Remove hardened concrete and foreign materials from the inner surface of the mixing and conveying equipment. Remove all debris from the space to be occupied by the concrete.
2. Remove water from the space to be occupied by the concrete before concrete is deposited. Divert any flow of water into an excavation through proper site drainage to a sump, or by other methods. If required by the Engineer, grout up any water vent pipes and drains after the concrete has thoroughly hardened.
3. Provide satisfactory redundancy in the delivery system so that work can continue in the event of a breakdown.
4. Do not use aluminum materials in pumping lines, transfer hoppers or chutes longer than 12 feet. Provide conveyor belts instead of chutes when the distance is longer than 50 feet. Use a storage hopper at the start of the line.
5. For pumped concrete, provide a hose with an angle-change, to create a back- pressure at the outlet.
6. Provide illumination if necessary, inside the forms, so that the placed concrete will be visible from the deck at top of formwork.
7. Provide thermometer for measuring concrete temperature when weather conditions are predicted to go beyond the range 50°F to 80°F.

B. Embedded Items:

1. Place all equipment, bolts, anchors, sleeves, inserts, structural steel members, angles and similar items that require embedment in the concrete.

2. All metal sleeves, inserts, anchors, and other embedded items shall be stainless steel unless shown otherwise. Set anchor bolts for equipment in templates, carefully plumbed and checked for location and elevation with an instrument and held in position rigidly by double nuts to the template to prevent displacement while concrete is being poured.
3. Aluminum items embedded in concrete shall not be allowed. Move reinforcement bars as necessary to avoid interference with other reinforcing steel, conduits, or embedded items, but not so as to impair design strengths of the member. If bars are moved more than two bar diameters, submit the resulting arrangement of bars for review.
4. Inspect the installation of all embedded items and reinforcing.

C. Placing:

1. Transfer the concrete to the place of final deposit as rapidly as practicable by methods that prevent the separation or loss of ingredients. Under no circumstances deposit partially hardened concrete in the work. Deposit concrete in the forms as nearly as practicable in its final position, to avoid re-handling. Maintain, until the completion of the pour, a plastic concrete surface, approximately horizontal.
2. Deposit concrete without segregation of the aggregate and without displacement of the reinforcement.
3. Maximum height of free fall for concrete during placement:
 - a. Concrete with maximum 4-inch slump: 4 feet
 - b. Concrete with high-range water reducing admixture and minimum 6-inch, maximum 9-inch slump:8 feet
4. Deposit concrete continuously or in layers 12 to 20 inches in depth so that no concrete will be deposited on concrete that has hardened sufficiently to cause the formation of seams or planes of weakness within the section. If a section cannot be placed continuously as originally planned, locate construction joints during the placement.
5. Use every means to secure a dense, impervious, homogeneous concrete, free from voids or pockets. If honeycomb, air, or rock pockets occur, repair the structure to the complete satisfaction of the Engineer, and modify the placing method or mix design, to prevent recurrence of deficient concrete. Provide such repairs and modifications at no additional cost. Extensive honeycomb or pockets may be cause for rejection of the work.

- D. Time Limit: Place all concrete in its final position in slab or forms within 1-1/2 hours of batching. Alternatively, as part of the mix design, provide admixtures that delay the initial set and state the proposed length of time in the submittal.
- E. Temperature Limits:
 - 1. Place all concrete in its final position in slab or forms at:
 - a. Less than 80°F, measured in the mix. See 3.2 B. 1.
 - b. More than 50°F, measured in the mix. See 3.2 B. 2.
 - 2. Refer to the vibration, concrete joints and curing sections for other requirements.

3.8 VIBRATION

- A. Compact the concrete with high frequency, internal mechanical vibrating equipment, and when required, supplement by hand spading and tamping. Consolidate slabs 6 inches or less in depth by hand tampers, spreading and settling with a heavy leveling straightedge.
- B. Operate vibrators with vibratory element submerged in the concrete, with frequency between 8,000 and 12,000 impulses per minute when submerged.
- C. Furnish sufficient vibrators to complete the compaction as specified without causing delay in the depositing of concrete. Provide at least one spare unit for each structure when concrete is being placed and at least one vibrator for each 25 cubic yards per hour of concrete placement.
- D. Vibrate by direct action in the concrete for approximately 10 seconds at approximately 12-inch intervals, not against forms or reinforcements. Do not move concrete horizontally by vibration. Work the concrete around the reinforcement, and around embedded fixtures and into the corners of the forms. Penetrate 6 to 12 inches into previously poured layers as new layers are poured, provided the running vibrator penetrates by its own weight. To secure even and dense surfaces, free from aggregate pockets, honeycomb, or air pockets, supplement vibration when required by forking or spading by hand or hammering the forms lightly opposite the freshly deposited concrete. Revibrate the final layer. Stop vibrating when concrete is thoroughly compacted and has ceased to decrease in volume and give off air bubbles.
- E. When placing concrete with 8-inch or more slump, reduce the time of vibration to 5 seconds and follow the admixture manufacturer's recommendations for technique.

3.9 CONCRETE JOINTS

A. General:

1. Provide joints:
 - a. As shown on the Drawings.
 - b. As required for constructability.
 - c. After approval of layout, sequence, and concrete placement program.
2. Provide minimum curing times before the second placement:
 - a. 2 days after the first concrete placement at the joint.
 - b. 10 days after each adjacent concrete placement, for infill pours.
3. During placement of the new concrete, ensure there are no interruptions to the 14-day curing time and 14-day load restriction plan for the adjacent pours.

B. Control Joints:

1. Space typical slab joints not exceeding 10 feet, or as shown on the Drawings.
2. If cast-in with the concrete, positively locate the preformed joint filler and hold rigidly in place during concreting.
3. If saw-cut, use a wheeled power saw as soon as the concrete surface is firm enough. Use overtime as required if outside normal work hours. Notify District a minimum of 3 days in advance if overtime may be needed.
4. Fill saw-cut grooves with sealant.

C. Construction Joints:

1. Produce quality concrete, with full continuity of reinforcing and water tightness across the joints unless otherwise detailed to control cracking.
2. Space typical slab joints not exceeding 20 feet in the direction of the transverse or secondary reinforcing, typically the smaller reinforcing nearer to the center of the slab thickness. Space typical vertical wall joints no more than 30 feet apart.

3. After the first concrete placement at the joint, do not walk on or disturb any reinforcing extending into the second placement area for at least 48 hours.
4. Before depositing new concrete on or against concrete that has hardened, clean and roughen the entire surface of the joint exposing clean coarse aggregate solidly embedded in mortar matrix. Provide 1/4-inch roughness or amplitude of the concrete surface measured from the top of the exposed aggregate to the bottom of pockets between stones.
5. Drench the prepared joint with clean water and remove prior to the concrete pour.
6. Cover horizontal wall and wall-to-slab joints with a minimum thickness of 1/2 inch and a maximum of 1 inch of grout immediately prior to placing new concrete.

D. Bonding to existing Concrete:

1. Mechanically roughen the old surface to 1/4-inch amplitude, as defined in construction joint paragraph above. Apply approved bonding adhesive, prior to concreting, per the manufacturer's recommended installation procedures.
2. Prepare (including replacement if required) existing saved reinforcing bars per Specification Section 03 01 30.62 Concrete Repair, Part 3.

3.10 CURING CONCRETE

A. General:

1. Cure concrete by methods specified in this Section.
2. Cure concrete minimum of 7 days.
3. Cure concrete to be painted with water or plastic membrane.
4. Do not use curing compound on concrete surfaces that are to receive paint or upon which any material is to be bonded.
5. Water cure or plastic membrane cure floor slabs, channel roof slabs and all concrete slabs which are specified to be sealed by concrete sealer.
6. Cure other concrete by water curing or sprayed curing membrane at Contractor's option.

B. Water Curing:

1. Keep surfaces of concrete being water cured constantly and visibly moist day and night for period of not less than 7 days.

2. Each day forms remain in place may count as 1 day of water curing.
3. No further curing credit will be allowed for forms in place after contact has once been broken between concrete surface and forms.
4. Do not loosen form ties during period when concrete is being cured by leaving forms in place.
5. Flood top of walls with water at least 3 times per day and keep concrete surfaces moist at all times during the 7 day curing period.

C. Sprayed Membrane Curing:

1. Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed.
2. If more than 1-hour elapses after removal of forms, do not use membrane curing compound, but apply water curing for full curing period.
3. If surface requires repairing or painting, water cure such concrete surfaces.
4. Curing Compound:
 - a. Do not remove curing compound from concrete in less than 7 days.
 - b. Curing compound may be removed only upon written request by the Contractor and acceptance by the Engineer, stating what measures are to be performed to adequately cure structures.
 - c. Take care to apply curing compound in area of construction joints to see that curing compound is placed within construction joint silhouette.
 - d. Remove curing compound placed within construction joint silhouette by heavy sandblasting prior to placing any new concrete.
 - e. Contractor's Option: Instead of using curing compound for curing of construction joints such joints may be water cured.
 - f. Apply curing compound by mechanical, power operated sprayer and mechanical agitator that will uniformly mix all pigment and compound. No hand pressurized tank sprayers will be allowed.
 - g. Apply compound in at least 2 coats.
 - h. Apply each coat in a direction of 90 degrees to preceding coat.
 - i. Apply compound in sufficient quantity so that concrete has uniform appearance, and that natural color is effectively and completely concealed at time of spraying.

- j. Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.
 - k. Thickness and Coverage of Compound: Provide compound having film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
 - l. Contractor is cautioned that method of applying curing compound specified herein may require more compound than normally suggested by manufacturer of compound and also more than is customary in the trade.
 - m. Apply amounts specified herein, regardless of manufacturer's recommendations or customary practice, if curing compound is used in place of water curing.
 - n. If Contractor desires to use curing compound other than specified compound, coat sample areas of concrete wall with proposed compound and also similar adjacent area with specified compound in specified manner for comparison.
 - 1) If proposed sample is not equal or better, in opinion of Engineer, in all features, proposed substitution will not be allowed.
 - o. Prior to final acceptance of the work, remove, by sandblasting or other acceptable method, any curing compound on surfaces exposed to view, so that only natural color of finished concrete is visible uniformly over entire surface.
- D. Plastic Membrane Curing:
- 1. Polyethylene film may be used to cure slabs. Seal joints and edges with small sand berm.
 - 2. Install plastic membrane as soon as concrete is finished and can be walked on without damage.
 - 3. Keep concrete moist under plastic membrane.
- E. Cold Weather Requirements: Provide adequate equipment for heating the placed concrete during freezing or near freezing weather:
- 1. Whenever the surrounding air temperature is below 40°F or may fall below 40°F within the 24-hour period after pouring of concrete, maintain all freshly poured concrete at not less than 50°F for 5 days.
 - 2. Keep the housing, covering, or other protection in place and intact at least 24 hours after the artificial heating is discontinued.

3. Do not use manure, salt, calcium chloride, or other chemicals on the concrete to prevent freezing.
- F. Hot Weather Requirements: Provide additional cooling to concrete when temperatures rise above 90°F, or low humidity, wind and temperature combine to cause high surface evaporation, over 0.2 lb./sq. ft./hour:
1. Provide additional water if curing by fog spray or ponding or saturated blankets.
 2. Provide shade to surfaces exposed to direct sunlight.
 3. Apply an evaporation retarder during the finishing operation, following the manufacturer's recommendation.

3.11 REPAIR OF DEFECTIVE CONCRETE

- A. Inspect all concrete surfaces immediately after carefully removing forms. Defective work includes concrete out of line, level or plumb; cracks; poor joints; rock pockets; honeycomb; voids; spalls and exposed reinforcing. Patch all minor defects, including form tie holes, before the concrete is thoroughly dry. Do not interrupt the curing program. Ensure that repairs match the existing surface for color and texture.
- B. Minor Defects:
1. Clean thoroughly, including removal of any curing compound. Cut out to solid concrete but to a depth of not less than 1 inch. Prepare the edges of the cut slightly more than perpendicular to the surface of the concrete, so as to form a key.
 2. Repair with cement mortar. Use minimum water, consistent with the requirements of handling and placing. Thoroughly compact the material into place and screed off to leave the patch flush with the surrounding surface.
 3. Keep the surface damp for at least 48 hours.
- C. Major Defects:
1. Large areas involving voids or rock pockets extending through the section may be cause for rejection of the work.
 2. If acceptable repairs can be made without adversely affecting the structural integrity of the work, cut out the section and either dry pack, or reform and re-pour to match the adjacent concrete. Do not cut out the reinforcing but cut keyways into the adjacent sound concrete to securely fasten the patch to the original work. Prepare edges of the damaged area with a minimum of a 1-inch cut perpendicular to the concrete surface.

3. Coat all surfaces with epoxy bonding compound immediately prior to patching. Place the concrete patch before the epoxy has set. Follow the epoxy bonding manufacturer's recommendations.
4. Provide a patch with strength and modulus of elasticity compatible with the parent concrete. Cure in accordance with the following article.

3.12 FIELD QUALITY CONTROL

A. Concrete Placement:

1. Verify that forms and reinforcement are accurately placed and secured in position. Confirm that both forms and reinforcement have been approved.
2. Verify that tie wire ends have been bent back away from the forms.
3. Verify that all sleeves, castings, pipes, conduits, bolts, anchors, and any other items required, are accurately and securely placed within or on the forms.
4. Verify adequate vibrators are available.
5. Verify construction joint faces have been prepared for the next concrete placement.
6. Check that the mix design is compatible with the method of placement of the concrete, by pump or by batch.
7. For wall placements, verify that the modified concrete mix required at construction joints is to be delivered.
8. Verify the concrete delivered to site is satisfactory, including checks on the batch tickets, quality assurance tests and direct observation of the batches.

B. Compressive Strength Tests:

1. See Article 1.4. Provide such facilities and equipment as are necessary to procure and handle representative samples of concrete, and to safeguard test cylinders stored at the site of the work.

C. Slump Tests:

1. See Article 1.4. Furnish all test equipment and perform tests observed by the Engineer.

D. Concrete Curing:

1. Verify procedures and equipment are available for controlling concrete temperature during hot and cold weather conditions.

2. Verify actual time of application of evaporation retardant, fog spray and curing materials for each placement.

3.13 E. CLEANUP

- A. Upon completion of all work performed under this Section, remove from the site all excess materials, storage facilities and temporary facilities. Smooth and clean of debris, all areas that were used or occupied during concrete construction operations and leave in clean condition.

END OF SECTION

SECTION 03 35 00

CONCRETE FINISHING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Finish formed and unformed surfaces of concrete.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 FINISHING UNFORMED SURFACES

A. General:

1. Surfaces shall contain just sufficient mortar to avoid the necessity for excessive floating.
2. Working of the surface in the various finishing operations shall be the minimum necessary to produce the desired finish.
3. Prevent the addition of water from rain or other sources to surfaces being finished.
4. Do not use finishing tools in areas where water has accumulated. Delay operations on such areas until the water has been absorbed, evaporated, or removed by draining, mopping, dragging off with a loop of hose, or other means.
5. Unformed surfaces which will be exposed to the weather, and which would normally be horizontal, shall be sloped for drainage. Narrow surfaces such as the tops of walls and curbs shall be sloped approximately 3/8 inch per foot of width. Broad surfaces, such as walks, roadways, platforms, and decks, shall be sloped approximately 1/4 inch per foot.

B. Finish U-S (unformed, screeded):

1. Use on pipe anchors and pavement repair.
2. Finishing operations consist of leveling and screeding the concrete to produce an even, uniform surface.
 - a. Remove surplus concrete after consolidation by striking it off with a sawing motion of the straightedge or template across wood or metal strips that have been set as guides.

C. Finish U-F (unformed, float finish):

1. Use on structures covered by backfill. May be done by hand or power-driven equipment.
2. Do not start floating until some stiffening has taken place in the surface concrete and the moisture film or “shine” has disappeared.
3. Float the concrete no more than necessary to produce a surface that is uniform in texture and free of screed marks. Light surface pitting is not objectionable.
4. If a troweled finish is to be applied, the floating shall leave a small amount of mortar without excess water at the surface to permit effective troweling.
5. Cut and fill shall be done during the floating operations.
6. Finish joints and edges with edging tools unless formed chamfers are indicated on the drawings.
7. Hair cracks are usually the result of a concentration of water and fines at the surface caused by over-manipulation during finishing operations. Cracking is aggravated by untimely finishing and by too rapid drying and cooling.
 - a. If low humidity may cause checking, keep surface moist temporarily with a very fine spray of water. Apply so as not to wash the surface nor form pools on it.
 - b. Checking that develops prior to troweling shall be closed by pounding the concrete with a hand float.
 - c. Water used for preliminary moistening shall be no colder (preferably warmer) than the concrete.
8. Flat surfaces with a U-F finish shall be plane within a tolerance of 1/4-inch in 10 feet as determined by a 10-foot straightedge placed anywhere on the slab in any direction.

D. Finish U-F2 (unformed, float finish after concrete partially hardened):

1. Use on unformed surfaces, unless otherwise specified.

E. Finish U-FB (unformed, broom finish):

1. Use where a non-skid surface is required.
2. Scored by brooming with a steel wire or stiff coarse-fiber broom before the concrete has hardened thoroughly.

F. Finish U-T (unformed, troweled):

1. Use where smoothness is essential.
2. Steel trowel after the moisture film and “shine” have disappeared from the floated surface and after the concrete has hardened enough to prevent an excess of fine material and water from being worked into the surface. Avoid excessive troweling. Perform with a firm pressure that will flatten and smooth the sandy surface left by the floating. Produce a dense uniform surface free of blemishes, ripples, and trowel marks.
3. The floating shall leave a small amount of mortar without excess water at the surface to permit effective troweling.
4. Obtain a fine textured surface that is not slick by applying a “sweat” or light “scroll” finish immediately after the first regular troweling. Trowel lightly over the surface with a circular motion, keeping the trowel flat on the surface of the concrete.
5. Flat surfaces with a UT finish shall be plane to within a tolerance of one-eighth inch in 10 feet as determined by a 10-foot straightedge placed anywhere on the slab in any direction.

G. Finish U-TB (unformed, troweled, hair brush finish):

1. Use on sidewalks and other concrete surfaces subject to foot traffic..
2. After floating and troweling and before concrete has hardened, score by brooming with a hair brush to produce a fine texture.

3.2 FINISHING FORMED SURFACES

A. General:

1. Fill form tie depressions and repair imperfections as specified in Section 03 30 00.
2. Repair surface irregularities as required for each finish.
 - a. “Abrupt” irregularities are offsets and fins caused by displaced or misplaced form sheathing, lining, or form sections, or by otherwise defective formwork.
 - b. All other irregularities are classed as “gradual” and will be measured with a 5-foot template consisting of a straightedge for plane surfaces or its equivalent for curved surfaces.

- B. Finish F-1 (formed, rough):
1. Use on surfaces upon or against which backfill, or concrete will be placed, or which will be permanently concealed.
 - a. Form sheathing may be anything that will not leak mortar when the concrete is vibrated.
 - b. Repair surface depressions greater than one inch.
- C. Finish F-2 (formed, smooth):
1. Use on exposed surfaces where a specific formed finish is not shown on the drawings.
 - a. Repair all conspicuous offsets and bulges and all surface irregularities exceeding 1/2-inch gradual and 1/4-inch abrupt.
 - b. Filling of air holes smaller than 1/2 inch, and sack rubbing are not required.
- D. Finish F-3 (formed, very smooth):
1. Use on superstructures of buildings, control and hydraulic structures, parapet walls, and railings.
 - a. Repair all visible offsets, bulges, misalignment, and all surface irregularities exceeding 1/4-inch gradual and 1/8-inch abrupt.
 - b. Sack rub air holes 1/8-inch and larger.

END OF SECTION

SECTION 03 62 00

NON-SHRINK GROUTING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work Included: Furnish and install non-shrink grout where shown on the drawings and as specified herein.

1.2 SUBMITTALS

- A. Submit in accordance with Section 01 33 00 - Submittal Procedures.
- B. Submit manufacturer's installation instructions and MSDS sheets fifteen (15) days prior to use.

1.3 PRODUCT STORAGE AND DELIVERY

- A. Grout shall be delivered in unopened containers bearing the manufacturer's name and type designation.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Cementitious grout:
 - 1. Cementitious nonshrink grout shall be high strength, nonmetallic and require only the addition of potable water. It shall have a minimum compressive strength at 28 days, per ASTM C 109 as modified by ASTM C 1107, of 7,500 psi when placed in a plastic consistency and 6,000 psi when placed in a flowable consistency.
 - 2. Manufacturers:
 - a. Masterflow 928 Grout, Masterflow 713 Grout, available from Muller Construction Supply, San Francisco, (415) 282-8001.
 - b. SikagROUT 212, available from D. M. Figley Co., Menlo Park, CA, (800) 292-9919.
 - c. Burke Non-Ferrous, Non-Shrink Grout 57-120, Burke Co., Oakland, (510) 465-3900.
 - d. U.S. Grout Corp. Five Star Grout, Five Star Products, Pleasanton, CA (925) 846-2803.
 - e. Or equal.

- B. Epoxy grout for base-plate grouting:
 - 1. Three-component, moisture-insensitive, 100 percent solids, epoxy adhesive having a minimum compressive strength at 28 days of 12,000 psi, a minimum bonding strength to concrete of 3,000 psi at 14 days, and minimum bonding strength to steel of 2,100 psi at 14 days.
 - 2. Manufacturers:
 - a. Sikadur 42 Grout-Pak, manufactured by Sika Corporation, local representative Brad Kamin, (925) 938-9336.
 - b. Escoweld 7505E/7530, manufactured by Escoweld, local representative Bay-Tech Associates, Novato, CA, (415) 639-7771.
 - c. Or equal.
- C. Epoxy grout for dowels:
 - 1. See Specification 05 50 10 – Anchor Systems.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Prepare and clean surfaces per manufacturer's recommendations.
- B. Mix and install according to manufacturer's instructions.
- C. See Specification 05 50 10 for dowels.

END OF SECTION

SECTION 05 05 14

HOT-DIP GALVANIZING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Hot-dip galvanize iron and steel items as shown on the drawings and as specified in this Section.
- B. Related Sections:
 - 1. Section 01 45 27 – Shop Inspections.
 - 2. Section 05 50 00 - Metal Fabrications.

1.2 REFERENCE STANDARDS

- A. ASTM International:
 - 1. A123 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - 2. A143 Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
 - 3. A153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - 4. A384 Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
 - 5. A385 Providing High-Quality Zinc Coatings (Hot-Dip)

1.3 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Applicator: Regularly engaged in application of hot-dip galvanized coatings for at least two years immediately prior to this work. Provide samples of coating operation for approval.
 - 2. Workers: Experienced and knowledgeable in preparation for and application of hot-dip galvanized coatings.

1.4 PRODUCT HANDLING, STORAGE AND DELIVERY

- A. Handle all products to be galvanized in such a manner as to avoid any mechanical damage and to minimize distortion.

- B. Load and store galvanized products to prevent formation of wet storage film.
 - 1. Stack or bundle galvanized products to allow air between the galvanized surfaces.
 - 2. Do not store galvanized products directly on the ground.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 SURFACE PREPARATION

- A. Pre-clean steel work utilizing an alkaline cleaner, acid pickle, and flux. Alternatively, the steel shall be blast cleaned and fluxed.

3.2 APPLICATION OF COATING

- A. Galvanize steel members, fabrications, and assemblies by the hot-dip process in accordance with ASTM A123.
- B. Galvanize bolts, nuts, and washers, and iron and steel hardware components in accordance with ASTM A153.
- C. Safeguard products against steel embrittlement in conformance with ASTM A143.
- D. Clean damaged surfaces of galvanized metals and touch up with zinc-rich paint conforming to ASTM A780. Extent of repair area to be approved by the Engineer.

3.3 INSPECTION

- A. All materials and workmanship shall be inspected to ensure that both fully meet these specifications. Any work found deficient shall be replaced and brought up to full compliance with these specifications.
- B. Provide notification for Engineer prior to coating application. See Section 01 45 27 for inspection advance notification requirements and District travel expenses.

3.4 FIELD REPAIRS

- A. The Engineer will determine whether items with defects or damage to coatings are to be returned to shop for recoating or whether touch-up in field is acceptable.
- B. Field touch-up of defects or damage to coatings shall be with a minimum of two coats of a compatible cold galvanizing product, as approved by the Engineer.

- C. Defect areas shall be slightly hand roughed up (not significantly removing galvanized coating) using 100 grit aluminum oxide sand paper including surrounding area within one inch of defect. Entire sanded area including defect shall be coated.

END OF SECTION

SECTION 05 05 24

WELDING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description:

1. Shop welding of stainless and steel fabrications.
2. Field welding of steel and stainless steel structural, pipe, fittings, and appurtenances.
3. Third-party independent inspection and examination of welds.

B. Related Sections:

1. Section 01 45 27 – Shop Inspection
2. Section 40 05 01 – Piping Systems
3. Section 40 05 24 – Steel Process Pipe

1.2 APPLICABLE CODES AND STANDARDS

- A. ASME Boiler & Pressure Vessel Code, Section V, Nondestructive Examination, including addenda, supplements, and interpretations.
- B. ASME Boiler & Pressure Vessel Code, Section VIII, Rules for Construction of Pressure Vessels, including addenda, supplements, and interpretations.
- C. ASME Boiler & Pressure Vessel Code, Section IX, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators, including addenda, supplements, and interpretations.
- D. AWS D1.1, Structural Welding Code – Steel.
- E. AWS D1.6 Structural Welding Code – Stainless Steel
- F. AWS 3.0, “Standard Welding Terms and Definitions” latest edition.
- G. AWS A2.4, “Standard Symbols for Welding, Brazing and Nondestructive Examination,” latest edition.

1.3 TERMS AND DEFINITIONS

- A. Certified Welding Inspector (CWI) – A person qualified as a welding inspector as given in AWS QC1-2007, Standard for AWS Certification of Welding Inspectors.

- B. Nondestructive Examination (NDE) – The act of determining the suitability of some material or component for its intended purpose using techniques that do not affect its serviceability.
- C. NDE Level II Technician/Operator (NDE Level II): An individual certified at Level II as defined in American Society for Nondestructive Testing (ASNT) Recommended Practice SNT-TC-1A specific to the NDE method used.
- D. Procedure Qualification Record (PQR) – A record of welding variables used to produce an acceptable test weldment and the results of tests conducted on the weldment to qualify a welding procedure specification.
- E. Welding Procedure Specification (WPS) – A document providing the required welding variables for a specific application to assure repeatability by qualified welders and welding operators. WPS's that are not prequalified by Code shall be supported with a PQR.
- F. Standard Welding Terms and Definitions. See AWS 3.0 “Standard Welding Terms and Definitions.”

1.4 SUBMITTALS

- A. Contractor's Welding Plan:
 - 1. The Contractor shall submit a Welding Plan listing each WPS to be used on the project and indexing that WPS to the drawing and weld.
- B. Welding Procedure Specifications:
 - 1. Submit WPS(s) and include each type of welding to be used including supporting PQRs for the WPSs that are not prequalified.
- C. Qualification of welders:
 - 1. Submit verifiable evidence of initial qualification for each welder for each weld that particular welder will use on the project.
 - 2. Submit verifiable evidence indicating each welder has maintained current qualification under the applicable code.
 - 3. For field welders, submit a schedule of required project qualification tests.
 - 4. Submit results of all field welder project qualification testing.
- D. Qualification of Inspectors and NDE Examiners:
 - 1. Submit verifiable evidence of the current CWI certification of all third party CWIs.

2. Submit verifiable evidence of the certification of all personnel performing NDE or interpreting the test results to ASNT-TC-1A Level II as a minimum.
- E. Provide all submittals to Engineer at least 15 workdays prior to welding.

1.5 QUALIFICATIONS

A. Welding Procedure Specifications:

1. All welds shall be completed in accordance with a qualified WPS.
 - a. The Contractor may use a prequalified WPS conforming to the provisions of AWS D1.1 – Clause 3 or AWS D1.6 – Clause 5, “Prequalification of WPSs
2. All WPS’s that are not prequalified as given above shall be qualified in accordance with one of the following:
 - a. ASME Boiler & Pressure Vessel Code, Section IX, or
 - b. AWS D1.1 – Clause 4
 - c. AWS D1.6 – Cause 6.
3. A CWI shall review and stamp all WPS’s and PQR’s.

B. Qualification of Welders, Shop:

1. Welders shall be qualified under ASME Boiler & Pressure Vessel Code, Section IX, Part QW; or AWS D1.1 – Clause 4, or AWS D1.6 – Clause 6, for the welding processes, positions, and procedures to be used for this project.
2. Welders shall have verifiable evidence they have maintained their qualifications in accordance with AWS D1.1 – Clause 4, or AWS D1.6 – Clause 6, or ASME Boiler & Pressure Vessel Code, IX, Part QW-322.

Welder Qualification(s) shall be witnessed and stamped indicating acceptance by a CWI.

C. Qualification of Welders, Field:

1. Prior to the start of welding on this project, each welder shall perform welder qualification testing specific to the welding on this project. Only welders that pass welder qualification testing for this project will be allowed to weld on this project. Prior welder qualification records will not be accepted. All welder qualification tests will be at the expense of the Contractor. Qualifications shall be in accordance with AWS D1.1-Clause

4 or AWS D1.6 – Clause 6 for each process, position and procedure to be used on the project.

2. Welder qualification testing shall be witnessed by a third party AWS CWI provided by and at the Contractor's expense. Upon successful completion of testing, the AWS CWI shall stamp, sign and date the welder qualification form.
3. The District and Engineer reserve the right to witness all welder qualification tests and be present for all weld coupon testing. Notify the Engineer a minimum of 10 work days in advance of all welder qualification tests.

D. Retesting of Welders Based on Quality of Work:

1. When the quality of a welder's work appears to be below the requirements of this specification or referenced Codes, the Engineer may require that the welder demonstrate an ability to produce sound welds by means of a simple test or by requiring complete requalification in accordance with AWS D1.1-Clause 4 or AWS D1.6 – Clause 6, or ASME Section IX as applicable. All re-qualifications will be at the Contractor's expense.

1.6 NONDESTRUCTIVE EXAMINATION-GENERAL

A. Types of NDE and Acceptance Criteria:

1. Radiographic Examination (RT) per Paragraph UW-51, Section VIII, ASME Boiler & Pressure Vessel Code.
2. Ultrasonic Examination (UT) per Paragraph UW-53, Section VIII, ASME Boiler & Pressure Vessel Code.
3. Liquid Penetrant (PT) per Section V, ASME Boiler & Pressure Vessel Code. Acceptance criteria shall be as given by AWS D1.1 - Clause 6, Part C or AWS D1.6 – Clause 8, Part D.

Magnetic Particle (MT) per Section V, ASME Boiler & Pressure Vessel Code. Acceptance criteria shall be as given by AWS D1.1 - Section 6, Part C.

B. Nondestructive Examination of Production Welds:

1. In addition to any NDE required by the Contract Documents, the Engineer may elect to perform additional NDE of in-process or completed shop or field welds to verify weld quality. Any additional NDE may be performed by District personnel or the Engineer may request the Contractor perform or subcontract these examinations.

2. Cost of Examinations:
 - a. The cost of NDE identified in the Contract Documents for specific welded connections shall be borne by the Contractor.
 - b. The cost of additional NDE requested by the District will be borne by the District in the event that all examined welds are found to be acceptable. In the event of a rejected weld, the Contractor shall bear the costs of all NDE, including NDE of weld seams found to be acceptable, as well as the costs of repairs, re-inspection and re-examination of the rejected weld.
3. The cost of NDE performed by District personnel will be borne by the District. The costs of repairs, re-inspection and re-examination resulting from a rejected weld shall be borne by the Contractor.

1.7 VERIFICATION

A. General Requirements:

1. All welds shall be visually inspected and accepted prior to performance of all NDE, including hydrostatic and air tests. Final visual inspection shall be performed after the weld has cooled to ambient temperature.
2. In-process and final inspections shall be documented on attached “Field Welding Inspection Form”, and available for review by the Engineer. At a minimum, all elements listed on the form are required.
3. All visual inspections and nondestructive examinations shall be completed and confirmed as acceptable by the Engineer prior to further processing that could interfere with access to the welded joint for repairs.

B. Required NDE, Field Welding:

1. NDE of the finished weld for stainless steel and carbon steel shall be:
 - a. Fillet and complete penetration welds: MT or PT.

C. Required NDE, Shop Welding:

1. NDE of the finished weld for pipe shall be:
 - a. Pipe fillet and complete penetration welds: PT
2. NDE of the structural steel shall be:
 - a. Fillet and complete penetration welds: MT or PT

D. Shop Inspection:

1. The Engineer will perform inspections and witness tests during all phases of fabrication.
2. Provide notification for Engineer to be present for testing. See Section 01 75 17 for inspection advance notification requirements and District travel expenses.
3. Failure to notify the Engineer to inspect or witness tests at the manufacturer's plant will result in rejection of all materials and items processed.
4. The Contractor shall provide third party independent CWIs and NDE Examiners for all fabrications. Third party inspectors and examiners shall be independent from work production and schedule responsibilities. Third party CWIs shall provide daily reports to the Engineer for all inspections performed. Welding inspections shall include as applicable: verification of welder and weld procedure specification; joint fit-up and tack; preheat; root or first pass inspection; verification of any required in-process NDE; interpass temperature; final visual inspection including weld quality and item dimensions, orientation and configuration. The reports shall provide a clear summary of the inspection activities performed, direct traceability to the work, and a determination of acceptability.
5. The District or Engineer will verify that the third party independent inspections and NDEs comply with these requirements, including referenced Codes and Standards, and will review and accept (or reject) the reports of the CWIs and Examiners. The District or Engineer may at any time verify by direct inspection or surveillance the acceptability of all phases of welding and third party independent inspection and NDE activities.

E. Field Inspection:

1. The Contractor shall provide third party CWIs and NDE Examiners. Third party inspectors and examiners shall be independent from work production and schedule responsibilities. Third party CWIs and NDE Examiners shall provide daily reports, documented on the attached "Field Welding Inspection Form" to the Engineer for all work performed. The reports shall be signed and stamped and provide a clear summary of the inspection or NDE activities performed, direct traceability to the work, and a determination of acceptability.
2. The District or Engineer will verify that the third party independent inspections and NDE comply with these requirements, including referenced Codes and Standards, and will review and accept (or reject) the reports of the CWIs and Examiners. The District or Engineer may at any time verify by direct inspection or surveillance the acceptability of all

phases of welding and third party independent inspection and NDE activities.

1.8 CHARPY V-NOTCH (CVN) TESTING

- A. For welding of steel, specials and fittings with a thickness of 0.406-inch and greater, heat input control and CVN testing is required.
 - 1. WPS for shop welding shall be qualified in accordance with ASME Boiler Pressure Vessel Code Section IX and shall include Supplementary Essential Variables.
 - 2. WPS for field welding shall be qualified in accordance with AWS D1.1 – Clause 4, Part B.
 - 3. PQRs shall be qualified for notch tough welding with consideration for thickness of steel, test temperature, and CVN values. Refer to AWS D1.1 - Clause 4, Part D, “Requirements for CVN Testing”.
 - 4. The number of CVN test specimens shall be per AWS D1.1 - 4.36.1, Option A - 3 specimens.
 - 5. As required to be specified by AWS D1.1 - 4.36.6, the CVN test temperature shall be 40-degF unless otherwise specifically called out on the drawings.
 - 6. The CVN test requirements for the minimum absorbed energy values, the minimum average percent shear area value, and the minimum average lateral expansion value shall be per AWS D1.1 - Table 4.14.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 GENERAL PROCEDURES

- A. Use Shielded Metal Arc Welding (SMAW), Flux Cored Arc Welding (FCAW), Gas Tungsten Arc Welding (TIG), or Gas Metal Arc Welding (Spray or Globular modes only), unless the Engineer approves another process prior to use.
- B. Gas Metal Arc Welding (Short-Circuit) is not allowed. All welds shall be made according to an approved WPS.
- C. Each step of the welding process will be inspected and approved before proceeding to the next step.
- D. Welding shall be performed in at least two layers. Passes shall not exceed 1/4 inch in throat dimension.
- E. Welds shall be thoroughly cleaned after each pass.

- F. Welds shall be fully fused with base metal, uniform in appearance, free from cracks and reasonably free from irregularities. Weld shall blend smoothly and gradually into the base material
- G. Restart in weld zone on clean and sound metal.
- H. Remove defective welds by chipping, grinding, flame gouging, or air-arc gouging and repair by re-welding.
- I. No undercut is allowed.
- J. Use procedures or welding sequences that will minimize eccentric stresses, shear or distortion in the weld.
- K. Butt welds, where authorized, shall have complete penetration and fusion.
- L. Finished weld bead shall be central to the seam.
- M. Artificial or forced cooling of welded joints is not permitted.
- N. Low hydrogen electrode storage shall be in accordance with AWS D1.1 - 5.3.2.1.
- O. Joining Dissimilar Metals
 - 1. When joining carbon steel to various stainless steels, the following filler material shall be used unless otherwise called out on the drawings:
 - a. Carbon steel to stainless steel: 309L filler material.
 - b. Carbon steel to type 316 or 316L stainless steel: 309L or 316L filler material.

3.2 STAINLESS STEEL-SPECIFIC PROCEDURES

- A. Welding and production processes are to conform to ASME B31.3.
- B. Use of Solar Flux is prohibited.
- C. Use of FCAW welding is prohibited.
- D. Pipe and fittings with wall thickness up to 11-gage (1/8-inch): weld using the TIG process.
- E. Pipe and fittings with wall thicknesses greater than 1/4-inch may be welded using an automated SAW process.
- F. Pipe and fittings with wall thickness greater than 11-gage (1/8-inch): Bevel and complete root pass using the TIG process, followed by subsequent passes with the TIG, or Metallic Arc SMAW process.
- G. Filler material:E316L (smaw/stick), ER316L (gmaw/gtaw), E316-X

- H. Add only ELC wire grades to provide a cross section at the weld equal to or greater than the parent metal.
- I. SMAW electrodes to conform to CSA W48.3.
- J. Make weld deposit smooth and evenly distributed and with a crown of no more than 1/16-inch on the I.D. and 3/32-inch on the O.D. of the piping. Concavity, undercut, cracks, or crevices are not permitted.
- K. Full penetration butt welds: provide inert gas shielding to the interior and exterior of the joint.
- L. Lap joints: provide full thickness seal welds on both joints.
- M. Remove excessive weld deposits, slag, spatter, and projections by grinding. Grind welds smooth on gasket surfaces. Tack welds, clips, and other attachments.
- N. Repair nicks, gouges, notches, and depressions in the base metal in the area before the joint weld is made.
 - 1. Remove tack welds, clips, and other attachments and repair defects, except where the tack welds occur within the weld area and these tack welds do not exceed the size of the completed weld. Remove cracked tack welds.
 - 2. Grind those areas to be repaired down to clean metal and then repair by building up with weld metal. Grind the repaired areas smooth to form a plane surface with the base metal.
- O. Defects and repairs.
 - 1. Remove welds with cracks, slag inclusions, porosity, undercutting, incomplete penetration, or which are otherwise deficient in quality or made contrary to any provisions of these specifications, by chipping or grinding throughout their depth to clean base metal.
 - 2. Do not perform calking or peening of welds to correct defects.
 - 3. Enlarge welds found deficient in dimension but not in quality by additional welding after thoroughly cleaning the surface of previously deposited metal and the adjoining plate.
 - 4. Remove weld deposits, slag, weld spatter, and projections into the interior of the pipe by grinding.
- P. Finish.
 - 1. Treat all welded joints with Avesta BlueOne™ 130 Pickling Paste or approved equal and rinse with clean water.

2. If rusting of embedded iron occurs, pickle the affected surface with Avesta BlueOne™ 130 Pickling Paste or approved equal.
3. Rinse clean using Avesta FinishOne Passivator 630 or approved equal.

3.3 STEEL-SPECIFIC PROCEDURES

- A. Except where the Piping System Schedule specifies compliance with ASME Pressure Piping Codes (ASME B31.1, ASME B31.3, etc.) make field welds per AWWA C206 using shielded metal arc, gas shielded arc, or submerged arc welding methods. Make welds per the specified Pressure Piping Code when these codes are specified for the Piping System in the Piping System Schedule.
- B. Provide double-groove (double-vee) circumferential welds for butt welds on 30 inch diameter and larger joints. Provide single-groove (single-vee) circumferential welds for butt welds on joints less than 30 inch diameter. If backing rings are used, completely remove them after welding is complete and deburr, grind, and clean the area per AWWA C206.

3.4 SUPPLEMENTS

- A. The following supplements follow END OF SECTION are a part of this section:
 1. Field Welding Inspection Form.

END OF SECTION

FIELD WELDING INSPECTION FORM

| | | | |
|---------------------------|--|------------------------------|--|
| Spec. Number | | Date | |
| General Contractor | | Welding Subcontractor | |
| Inspection Co | | CWI NAME & # | |

WELDING INSPECTION RECORD

| <i>LOCATION DESCRIPTION</i> | <i>STATION</i> | <i>PC MKS</i> | <i>DWG DETAIL REF.</i> | <i>WELDER ID</i> | <i>WPS</i> | <i>JOINT FIT-UP AND FIELD TOP</i> | <i>ROOT PASS (GROOVE) *FIRST PASS (FILLET)</i> | <i>BACK GOUGE VISUAL/NDT</i> | <i>FINAL VISUAL</i> |
|-----------------------------|----------------|---------------|------------------------|------------------|------------|-----------------------------------|--|------------------------------|---------------------|
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

DESCRIBE ALL IN-PROCESS REWORK: _____

ALL WORK AS LISTED IS IN CONFORMANCE WITH THE CONTRACT DOCUMENTS

| | |
|--|--|
| <i>FINAL ACCEPTANCE : STAMP / DATE /SIGNATURE</i> | |
|--|--|

Sketches:

SECTION 05 12 00

STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Furnish and install structural steel elements as shown on the structural drawings and as specified herein.
- B. Related work specified elsewhere:
 - 1. Section 01 45 27 – Shop Inspection.
 - 2. Section 05 50 00 – Metal Fabrications.
 - 3. Section 09 90 00 – Painting and Coatings.

1.2 QUALITY ASSURANCE

- A. Qualifications of Workmen:
 - 1. A foreman experienced in the work being done shall be on the job at all times.
 - 2. The Contractor shall qualify all welders and welding procedures in accordance with the latest edition of AWS D1.1, Section 4, Structural Welding Code - Steel. Notify the Engineer in advance of welder and welding procedure qualification so the Engineer may witness qualification.
- B. Codes and Standards:
 - 1. All fabrication and erection of steel elements shall conform to AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings" and the "Code of Standard Practice for Steel Buildings and Bridges" except as modified by the applicable building codes, unless specified otherwise.
 - 2. Welding shall be by the shielded metal arc, gas metal arc (spray arc mode), gas shield flux cored arc (dual shield) or submerged arc welding processes and shall be in accordance with AWS D1.1, Structural Welding Code.
 - 3. Electrodes used for the gas metal arc (GMA) process shall conform to AWS A5.18. Electrodes used for the flux cored arc welding (FCAW) process shall conform to AWS A5.20. See AWS D1.1, Table 3.1 for details.

4. Low hydrogen electrode storage shall be in accordance with AWS D1.1, Article 4.5.

C. Testing and Inspection:

1. The Contractor shall provide independent inspection of all structural steel framing welds and nondestructive examination (NDE) as indicated on applicable drawings. The District will perform direct visual verification of these inspections and tests. Notify the District's Plant Inspection Section at 510/287-1132 for all field and shop inspections and tests.
2. Welding inspection personnel shall be qualified in accordance with AWS QC1 at the level of Certified Welding Inspector.
3. NDE personnel shall be certified in accordance with ASNT-TC-1A Level II as a minimum.
4. Inspections and test results shall comply with AWS D1.1 Section 6 for the related inspection and test method.
5. The costs of all inspections and tests, including retests after repair, shall be borne by the Contractor.

D. Tolerances:

1. Dimensional tolerances and allowances for fit shall be in accordance with applicable AWS Standards unless shown otherwise. Tolerances and allowances shall be shown on the Contractor's erection or working drawings.

E. Mechanical Fasteners:

1. Mechanical fasteners may be added to the structural joints to facilitate field erection. But unless otherwise approved by the Engineer, these fasteners shall not allow the Contractor to waive the required welded connections shown in the structural drawings.

1.3 SUBMITTALS

- A. Submit all welding procedures and welder qualification records using forms provided in the appendix to AWS D1.1 welding code prior to any production welding.

B. Certifications:

1. Submit current certifications of welders' qualifications as per AWS D1.1, paragraph 5.30 prior to welding work. Welder certifications shall verify the qualifications for the welding process and procedure to be used.

2. Submit certifications, mill tests, or reports from an approved independent testing laboratory for the conformance of structural steel to be used with the specified ASTM requirements.

C. Fabrication Drawings:

1. Submit fabrication drawings for Engineer's review prior to fabrication. Drawings shall not be reproductions of contract drawings. Include complete information for the fabrication and erection of the structure's components, including location, type, and size of bolts, welds, member sizes and lengths, connection details, blocks, copes, cuts and cambers. Use AWS standard welding symbols.

D. Erection Drawings:

1. The drawings shall indicate methods of installation, the location of any item substitutions, and details requiring coordination and/or installation by other trades.

E. Substitutions Proposed by the Contractor:

1. Submit the information on substitutions for structural details shown in the drawings for the Engineer's approval. Submit complete design calculations for the substitutions for structural details signed by a California registered Civil or Structural Engineer.

1.4 PRODUCT HANDLING

- A. Store and protect materials in a manner to maintain identification, to prevent damage, and to prevent corrosion.
- B. In the event of damage, immediately make all repairs and replacements necessary as approved by the Engineer.

1.5 COORDINATION

- A. The Contractor shall coordinate installation of bucks, anchors, blocking, drains, pipes, electrical and mechanical work which is to be placed in or behind partition framing and allow such items to be installed after framing is complete.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Structural Steel: All hot rolled steel plates, shapes, sheet piling, and bars shall be new steel conforming to ASTM A6.
 1. Structural steel wide flange and WT-shapes, unless noted otherwise, shall conform to ASTM A992.

2. Structural steel M-shapes, S-shapes, channels and angles, unless noted otherwise, shall conform to ASTM A36.
 3. Steel for structural tubes shall conform to ASTM A500, Grade B.
 4. Steel for structural pipe members shall conform to ASTM A53, Grade B.
- B. Miscellaneous metal accessories and structures:
1. Steel for miscellaneous metal accessories and structures unless specified otherwise, shall conform to ASTM A992 or A36.
- C. Bolts for structural steel connections: ASTM A325-, Type N.
- D. Anchor bolts: ASTM F1554, Grade 36. .
- E. Anchor rods: Type 316 stainless steel per ASTM F593, Group 2.
- F. Galvanizing: All metal items situated in pits at any distance at all below main finish floor elevation shall be hot dip galvanized after fabrication.
- G. Stainless steel: Stainless steel shall be type 316 (316L for welded items). Anchor bolts, and bolts, washers and nuts for steel member connections shall be stainless steel conforming to ASTM F593 and F594, unless otherwise noted. Stainless steel bolts shall have a minimum yield strength (Fy) of 45ksi and tensile strength (Fu) of 85ksi.

PART 3 - EXECUTION

3.1 VERIFICATION

- A. Examine areas and conditions under which structural steel elements are to be installed.
- B. Correct conditions detrimental to the proper and timely completion of the work.
- C. Do not proceed until unsatisfactory conditions have been corrected to the Engineer's satisfaction.

3.2 FABRICATION

- A. All structural items shall be carefully fabricated to true dimensions without warp or twist. Welded closures shall be neatly made; and where weld material interferes with fit or is unsightly in appearance, it shall be ground off smooth. Weld profile shall meet AWS D1.1, paragraph 3.6 requirements.
- B. All structural steel shall be shop primed. See Section 09 90 00.

3.3 CERTIFY THAT PRIMERS APPLIED TO METAL SURFACES IN THE SHOP ARE COMPATIBLE WITH COATING TO BE APPLIED OVER SUCH PRIMERS IN THE FIELD. INSPECTION

- A. All materials and workmanship will be inspected to ensure that both fully meet these specifications. Any work found deficient must be replaced and brought up to full compliance with these specifications.
- B. Provide notification for Engineer to be present for fabrication.

3.4 ERECTION AND INSTALLATION

- A. The Contractor shall take all measurements necessary to properly fit his work in the field. The Contractor shall be responsible for the correct fitting of all metalwork in the field.
- B. Redrilling, reshaping, or forcing to fit any fabricated item will not be permitted. The Contractor shall be responsible for placing anchor bolts or other anchoring devices accurately and making any surfaces which bear against structural elements smooth and true to level. Provide manufacturer's data for installation and testing of anchorages.
- C. Structural items needing a special alignment to preserve straight, level, even, smooth lines shall be rigidly supported and braced and kept braced until concrete, grout, or dry pack cement mortar has hardened for period of not less than 7 days.

END OF SECTION

SECTION 05 50 00

METAL FABRICATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Fabricate and install miscellaneous metal work as shown on the drawings and specified herein.
- B. Related work specified elsewhere:
 - 1. Section 01 33 00 – Submittal Procedures.
 - 2. Section 05 05 14 – Hot-Dip Galvanizing.

1.2 QUALITY ASSURANCE

- A. Design, fabrication, and erection of structural steel, steel assemblies and shop and field welding shall meet applicable requirements of the AISC Specifications.
- B. Application of zinc (hot-dip galvanized) coatings to metal fabrications shall conform to Section 05 05 14.
- C. Aluminum welding shall conform to ANSI/AWS D1.2 latest edition Structural Welding Code - Aluminum "Suggested Specifications for Structures of Aluminum Alloys 6061-T6" unless otherwise noted.
- D. Stainless Steel welding shall conform to ANSI/AWS D1.6 latest edition - Structural Welding Code-Stainless Steel.

1.3 SUBMITTALS

- A. Submit complete fabrication and erection drawings for the Engineer's approval prior to cutting or fabrication. Shop drawings shall show the details of fabrication with weld symbols in accordance with AWS A2.4 for all joints to be welded.
- B. Certification of Welders:
 - 1. Submit verifiable evidence of initial qualification for each welder.
 - 2. Submit verifiable evidence each welder has maintained current qualification(s).
- C. Submit WPS's with supporting PQR's for approval.
- D. Provide all submittals to Engineer at least 14 work days prior to commencing welding, except that WPS's and PQR's shall be submitted 44 work days prior to commencing welding.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Structural Steel: All hot rolled steel plates, shapes, sheet piling, and bars shall be new steel conforming to ASTM A6.
 - 1. Standard rolled steel sections: ASTM A992, Grade 50.
 - 2. Steel structural tubing: ASTM A500, Grade B.
 - 3. Nonstructural steel bars, angles, rods, clips, brackets, supports, and similar items: ASTM A36.
- B. Stainless steel plate: ASTM A240, Type 304L.
- C. Stainless steel tubing: ASTM A269. Type 304L and 316L
- D. Aluminum: Rolled or extruded from 6061 T6 alloy, ASTM B308 and B632, except as shown on the Drawings.
- E. Steel bolts:
 - 1. All except flanges and anchor bolts, ASTM A325, Type N.
 - 2. Flanges, Section 05 05 26.
 - 3. Anchor bolts and rods, as specified below.
- F. Stainless steel bolts:
 - 1. All except flanges and anchor bolts, ASTM F593-S8, Type 304 or 316.
 - 2. Flanges, Section 05 05 26.
 - 3. Anchor bolts and rods, as specified below.
- G. Steel Pipe: ASTM A53, Grade B.
- H. Steel pipe bollards:
 - 1. Minimum length of post shall be 80".
- I. Stair treads:
 - 1. NAAMM, grating manufacturer's standard 19-W-4 steel with 2-1/2" x 3/16" carrier plates and abrasive nosing.
 - 2. Hot dip galvanize after fabrication.
 - 3. Bearing bars shall be 1 1/2" x 3/16".

4. Treads shall be serrated.
5. Acceptable products:
 - a. Amico Grating, Welded (checked plate nosing)
 - b. Harsco Industrial IKG, Type WB.
 - c. McNichols, Type B – GW 150.
 - d. Or equal as approved by the Engineer.
- J. Non-slip tread nosing:
 1. Acceptable products:
 - a. Ferrogrit Type 101, Wooster Products Inc.
 - b. Feracast Style 950, American Mason Safety Tread Co.
 - c. Or equal as approved by the Engineer.
- K. Grating:
 1. Band all openings interrupting three or more bearing bars, and all grating edges, with band bars having equivalent dimensions to bearing bars.
 2. Hot-dip galvanize after fabrication.
 3. Grating shall be free of warp, twist or other defects affecting appearance or serviceability.
 4. Bar dimensions as shown on drawings.
- L. Guard chain: ASTM A413, Class Grade 28, 0.218" diameter, galvanized.
- M. Self-Closing Safety Gate:
 1. Gate Arm: To be a minimum of 1-1/4" x 1-1/4" 11-gauge formed mild steel (ASTM A569) or stainless steel, type 316 (ASTM A554) members. Finished product to be capable of meeting U.S. Federal OSHA Loading Requirements at time of manufacturing. Minimum dimension from top of gate arm to bottom of gate arm to be 22". Gate arm to be furnished in dimension and type capable of engaging adjacent railing column.
 2. Pivot Clamp Bracket: Universal clamp bracket to be formed 10-gauge mild steel (ASTM A569) or stainless steel, type 316 (ASTM A240) shape capable of fitting railing columns up to 2" O.D, adaptable to flat surfaces, and welded installation. Provide four (4) zinc plated or stainless-steel U-Bolts, four (4) zinc plated or stainless steel nylon inset lock nuts, and four (4) zinc plated or stainless steel flat washers per gate. Hinge pivot

hardware to include two (2) nylon bearing washers, one (1) 5/16"-18 x 3" hex bolt, and one (1) 5/16"-18 nylon inset lock nut per hinge bracket.

3. Hinge Plate: To be full height 10-gauge formed mild steel (ASTM A569) or stainless steel, type 316 (ASTM A240) plate and provide for gate arm adjustment of 3-3/4" (-1-1/4" to +2-1/2" from nominal gate size) minimum total horizontal adjustment. Adjustment hardware, factory assembled, to include four (4) 5/16"-18x 1-3/4" carriage bolt, four (4) flat washers, and four (4) nylon inset lock nuts. Hardware to be zinc plated on all mild steel gates regardless of finish. Stainless steel gate to have stainless steel hardware.
4. Hinge Springs: To be torsion type, stainless steel (type 316) on all gates. Provide two (2) springs per gate, housed within hinge pivot.
5. Finish: All exposed surfaces to be one of the following types:
 - a. Mild Steel with Powder Coat Safety Yellow; TGIC Polyester. Fasteners to be zinc plated.
 - b. Hot Dip Galvanized. Fasteners to be zinc plated.
6. Gate Operation: To allow a minimum of 180° travel and is reversible by inverting or rotating gate.
7. Packaging: Each gate to be fully assembled, individually boxed, and labeled with appropriate size and finish identifier clearly identified on exterior of carton. All mounting hardware, to include Standard U-bolts for 1-1/2" O.D. railing mount and installation instructions shall be packaged and attached to gate assembly.
8. Acceptable products:
 - a. Kee Safety, Model LSG
 - b. Bluewater Manufacturing, GuardDog Industrial Safety Gate
 - c. Or equal as approved by the Engineer.

N. Epoxy adhesive anchors:

1. Anchor rods: Type 316 Stainless Steel per ASTM F593, Group 2.
2. All epoxy adhesive anchors shall be designed and installed per the requirements of ACI 318 Chapter 17 as amended by ICC-ES AC308.
3. Acceptable epoxy adhesive (Must have a current ICC-ES Evaluation Report):
 - a. HIT-HY 200 Fast Cure Hybrid Adhesive, Hilti Corp.

- b. SET-XP High-Strength Anchoring Adhesive, by Simpson Strong-Tie.
 - c. Or equal as approved by the Engineer.
 - O. Expansion type anchor bolts shall only be used for static loads and shall not be loaded by vibrating or rotating equipment. Thread length to suit intended use.
 - 1. Acceptable products in concrete:
 - a. Strong-Bolt 2 by Simpson Anchor Systems.
 - b. Kwik-Bolt TZ by Hilti Corp.
 - c. Or equal as approved by the Engineer.
 - P. High Strength Anchor Bolts:
 - 1. Bolts shall conform to ASTM F1554.
 - 2. Nuts shall conform to ASTM A563, and washers shall conform to ASTM F436.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Verify measurements at the job.
- B. Perform all cutting, drilling, punching, threading and tapping required for miscellaneous metal or adjacent work.
- C. Grind all sharp metal edges on items to be painted or coated. Edges shall be rounded.
- D. Welds:
 - 1. Weld nonremovable connections in weldable materials unless noted otherwise.
 - 2. Grind all rough weld beads. Welds exposed to view shall be uniformly neat.
 - 3. Welds shall be abrasive blasted prior to galvanizing. All slag and other weld irregularities shall be removed prior to galvanizing.
- E. Punch holes 1/16-inch larger than the nominal size of the bolts, unless otherwise indicated. Whenever needed, because of the thickness of the metal, holes shall be sub-punched and reamed or shall be drilled. Correct unmatched holes with new material or new reaming at the Engineer's discretion. No drifting of bolts nor enlargement of holes will be allowed to correct misalignment.

- F. Protect dissimilar metals from galvanic corrosion by means of pressure tapes, coatings, or isolators as approved. Protect aluminum in contact with concrete or grout with a heavy coat of mastic.
- G. Stainless steel parts, assemblies, and equipment shall be thoroughly cleaned, descaled and passivated in accordance with ASTM A380, Standard Practice for Cleaning, Descaling and Passivation of Stainless Steel Parts, Equipment, and Systems. The method of passivation to be used shall be in accordance with ASTM A967, Standard Specifications for Chemical Passivation Treatments for Stainless Steel Parts and submitted to the Engineer for approval prior to passivation work.
- H. After installation, clean damaged surfaces of shop coated metals and touch up with the same material used for the shop coat. Clean damaged surfaces of galvanized metals and touch up with zinc-rich paint conforming to ASTM A780.

3.2 INSPECTION

- A. All materials and workmanship may be inspected for conformance to these specifications. Any work found deficient must be replaced and brought up to full compliance with these specifications.
- B. See Section 01 45 00 for inspection advance notification requirements and District travel expenses.

END OF SECTION

SECTION 05 50 10

ANCHOR SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Includes: Complete anchoring systems in concrete including, but not limited to, equipment anchors and reinforcement dowels.

1. Anchor Bolts.
2. Adhesive Anchor Systems.
3. Expansion Anchors.
4. Undercut Anchors.

B. Related Sections:

1. Section 03 20 00 - Concrete Reinforcing.
2. Section 03 30 00 - Cast-In-Place Concrete.
3. Section 05 50 00 - Metal Fabrications.

1.2 REFERENCES

A. American Concrete Institute:

1. 355.2-07 Qualification of Post-Installed Mechanical Anchors in Concrete.
2. 355.4-11 Qualification of Post-Installed Adhesive Anchors in Concrete.

B. American Institute of Steel Construction (AISC):

1. Specification for Structural Steel Buildings.

C. American Society for Testing and Materials (ASTM):

1. A 36 - Specification for Structural Steel.
2. A123 - Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
3. A 307 - Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
4. F 593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

- D. International Code Council (ICC):
 - 1. 2018 International Building Code (IBC).

- E. California Building Standards Commission
 - 1. 2019 California Building Code (CBC).

1.3 SUBMITTALS

- A. Submit in accordance with Section 01 33 00 Submittal Procedures.
- B. Product Data: Fully describe every product proposed for use and manufacturer's installation instructions.
- C. Qualifications of Installer and Testing Laboratory
 - 1. Submit Installer's qualifications and training date per Paragraph 1.4 A. 1.
 - 2. Submit Testing Laboratory's qualifications.
- D. Test Reports:
 - 1. International Code Council Evaluation Service, Inc. (ICC-ES), Evaluation Service Reports based on the following acceptance criteria:
 - a. AC308 – Adhesive Anchors and Dowels.
 - b. AC193 – Expansion Anchors and Undercut Anchors.
 - 2. Field inspection reports by Special Inspector.
 - 3. Field tension test reports per Paragraph 3.3 C. Include type, manufacturer and model of anchor.

1.4 QUALITY ASSURANCE

- A. Installer's Qualifications: Adhesive system, expansion and undercut anchors shall be installed by an installer who has:
 - 1. A minimum of one year (1) of experience performing similar installations.
 - 2. A thorough training with manufacturer or manufacturer's representative on the project. Training shall consist of review of complete installation for adhesive anchors and dowels, and expansion anchors, to include but not limited to:
 - a. Hole drilling procedure.
 - b. Hole preparation and cleaning technique.

- c. Adhesive injection technique and dispenser training.
- d. Rebar dowel preparation and installation.
- e. Proof loading and torque tightening.

B. Special Inspections and Testing:

- 1. Comply with 2019 CBC, and Article 3.3 of this Section. Independent special inspections and testing for anchor systems shall be paid by the Contractor.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packing and Shipping: Deliver bolts free from mill scale, rust, and pitting.
- B. Storage and Protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cast-In-Place Anchor Bolt System:

- 1. Bolts and nuts: Type 316 stainless steel conforming to ASTM F593, unless otherwise indicated on Drawings.
 - a. Mechanical Properties:
 - 1) $f_y = 45$ ksi, min.
 - 2) $f_u = 85$ ksi, min.
- 2. Washers: Type 316 stainless steel conforming to ASTM A240, unless otherwise indicated on Drawings.
- 3. Anchor bolts, nuts and washers: Hot-dip galvanized ASTM A307 steel or hot-dip galvanized ASTM A36 steel, when indicated on Drawings.
- 4. All anchor bolts shall have a standard hex bolt head, unless otherwise indicated on Drawings.

B. Adhesive Anchor System:

- 1. Adhesive (not within tanks or channels):
 - a. Seismic qualified for 2018 IBC and tested per ICC-ES AC308.

- b. Used with all-threaded rods, internally-threaded inserts, or deformed reinforcing bars in cracked and un-cracked concrete per Evaluation Service Report (ESR).
 - c. Meet requirements of AASHTO specification M235, Type IV, Grade 3, Class A, B, or C except gel times.
 - d. Injectable two-component epoxy adhesive furnished in containers which keep component A and component B separate. Containers shall be designed to accept static mixing nozzle which thoroughly blends component A and component B and allows injection directly into drilled hole. Use injection tool and static mixing nozzles recommended by manufacturer.
 - e. Properties:
 - 1) Bond Strength (ASTM C882): 1,800 psi, Min.
 - 2) Compressive Strength (ASTM D695): 12,000 psi, Min.
 - 3) Compressive Modulus (ASTM D695): 0.22×10^6 Min.
 - 4) Tensile Strength 7 days (ASTM D638): 6,310 psi, Min.
 - 5) Elongation at Break (ASTM D638): 2%
 - 6) Heat Deflection Temperature (ASTM D648): 146°F
 - 7) Absorption (ASTM D570) 0.06%
 - 8) Linear Coefficient of Shrinkage on Cure (ASTM D2566) 0.004
 - f. Do not use adhesive with all-threaded rods, internally-threaded inserts, or deformed reinforcing bars to resist tension in overhead position unless otherwise indicated on drawings or specified.
 - g. Manufacturers: one of the following or equal:
 - 1) Hilti, HIT-RE 500 V3.
 - 2) Simpson Strong-Tie, SET-XP Epoxy Adhesive.
2. Adhesive (within tanks)
- a. Adhesive for reinforcing steel dowels shall have methacrylate or epoxy resin in composition of the adhesive.

b. Properties:

- 1) Compressive Strength (ASTM C579 or D695): 7,200 psi Min.
- 2) Chemical Resistance:
 - a) Sulfuric Acid: 10% Concentration
 - b) Hydrochloric Acid: 10% Concentration; and
 - c) Sea Water.

c. Adhesive shall be furnished in containers which keep component A and component B separate. Containers shall be designed to accept static mixing nozzle which thoroughly blends components A and B, and allows injection directly into drilled hole. Use injection tool and static mixing nozzles recommended by manufacturer.

d. Manufacturers: One of the following or equal:

- 1) Hilti, HIT-HY 200 Adhesive Anchor System.
- 2) Simpson Strong-Tie, SET-XP Epoxy Adhesive

3. Anchors:

a. Anchors shall be all-thread rods and shall be Type 316 stainless steel conforming to ASTM F593 (AISI 304/316 SS) condition CW unless otherwise indicated on Drawings.

- 1) Mechanical Properties:
 - a) $f_y = 45$ ksi, min.
 - b) $f_u = 85$ ksi, min.

b. All-thread rods shall be furnished with chamfered ends so that either end will accept a nut and washer. If recommended by the manufacturer, one end shall have a 45-degree chisel point that will be inserted into adhesive-filled hole.

c. All-thread rods shall be free of oil or coatings that may reduce bond.

d. Manufacturers:

- 1) Hilti, HIT-HAS, 316SS, for all-threaded rods.
- 2) Or equal.

4. Internally-Threaded Inserts:
 - a. Inserts shall be Type 316 stainless steel conforming to DIN EN 10088-3 unless otherwise indicated on Drawings.
 - 1) Mechanical Properties:
 - a) $f_y = 50$ ksi, min.
 - b) $f_u = 100$ ksi, min.
 - b. Use hex cap screws with internally-threaded inserts when anchors are to be removable as indicated on drawings.
 - c. Hex cap screws shall be Type 316 stainless steel conforming to ASTM F593.
 - 1) Mechanical Properties:
 - a) $f_y = 45$ ksi, min.
 - b) $f_u = 85$ ksi, min.
 - d. Manufacturers:
 - 1) Hilti, HIS-R Insert X5CrNiMo17122K700 Stainless Steel.
 - 2) Or equal.
5. Dowels:
 - a. Newly rolled deformed billet-steel reinforcing bars conforming to ASTM A615, Grade 60.
 - b. Embedment, splice and development lengths as specified and indicated on Drawings.
 - c. Dowels shall be free of oil, grease, paint, dirt, mill scale, dust, or other coatings that will reduce bond
 - d. Provide same dowel size and spacing as the reinforcing to which they are spliced.
 - e. Detail and fabricate reinforcing bars to provide specified cover to outer edge of steel and other installed items as indicated on Drawings.
 - f. If recommended by the adhesive manufacturer, one end shall have a 45-degree chisel point that will be inserted into adhesive-filled hole.

C. Expansion Anchor System:

1. Seismic qualified for 2018 IBC and tested per ICC-ES AC193.
2. Expansion anchor shall be suited to seismic and cracked concrete application.
3. Anchor shall be torque-controlled. wedge-type, with a single piece three-section wedge and fully treaded stud, completed with required nuts and washers. Anchor shall meet description of Federal Specification A-A 1923A, Type 4.
4. Anchor bodies, wedges, nuts and washers shall be Stainless Steel, Type 316. Studs and wedges shall conform to ASTM A276 or ASTM F593. Nuts shall conform to ASTM F594, and washers ASTM A240.
 - a. Mechanical Properties:
 - 1) $f_y = 76$ ksi, min.
 - 2) $f_u = 100$ ksi, min.
5. Do not use expansion anchors to resist tension in overhead position unless otherwise indicated on Drawings.
6. Manufacturers: One of the following or equal:
 - a. Hilti, Kwik TZ2 Expansion Anchor
 - b. Simpson Strong-Tie, Strong Bolt 2 Wedge Anchor

D. Undercut Anchor System:

1. Seismic qualified for 2018 IBC and tested per ICC-ES AC193.
2. Undercut anchors shall be suited to seismic and cracked concrete application.
3. Undercut anchors shall be of an undercut style with brazed tungsten carbides on the embedded end that perform self-undercutting process. Undercut portion of anchor shall have a minimum projected bearing area equal to or greater than 2.5 times the nominal bolt area conforming to ISO 898 Class 8.8 strength requirements.
4. Undercut anchors shall be stainless steel conforming AISI 316 or 316Ti.
 - a. Mechanical Properties:
 - 1) $f_y = 87$ ksi, min.
 - 2) $f_u = 116$ ksi, min.

5. Use undercut anchors to resist tension in overhead position as indicated on Drawings.
6. Manufacturers:
 - a. Hilti, HDA Undercut Anchor.
 - b. Or equal.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.2 ERECTION

A. General:

1. Verify length of bolt or dowel projection from concrete. Obtain bolt and fabricate dowel with length providing minimum embedment as required.

B. Anchor Bolts:

1. Use templates to locate bolts accurately and securely in formwork.
2. Accurately locate anchor bolts embedded in concrete with bolts perpendicular to surface from which they project.
3. Do not allow anchor bolts to touch reinforcing steel.
4. Where anchor bolts are within $\frac{1}{4}$ inch of reinforcing steel, isolate with a minimum of 4 wraps of 10 mil polyvinyl chloride tape in area adjacent to reinforcing steel.
5. In anchoring machinery bases subject to heavy vibration, use 2 nuts, with 1 serving as a locknut.
6. Where bolts are indicated on the Drawings for future use, first coat thoroughly with non-oxidizing wax, then turn nuts down full depth of thread and neatly wrap exposed thread with waterproof polyvinyl tape.
7. Furnish anchor bolts with standard hex bolt head unless otherwise indicated on the Drawings. Where anchor bolts with 90 degree hooks are indicated on the Drawings, provide anchors with minimum 4 diameter hook length.
8. Embed anchor bolts 10 diameters minimum unless otherwise indicated.

9. Where indicated on Drawings, set anchor bolts in metal sleeves having inside diameter approximately 2 inches greater than bolt diameter and minimum 10 bolt diameters long. Fill sleeves with grout when a machine or other equipment is grouted in place.

C. Adhesive Anchor System

1. Accurately locate rods, inserts or dowels, and set perpendicular to surfaces from which they project.
2. Do not use adhesive anchor to substitute for anchor bolt unless approved by the Engineer.
3. Do not install rods, inserts or dowels until the concrete has reached the specified 28-day compressive strength.
4. Do not fabricate or purchase rod, inserts or dowels until drill-ability of holes and accessibility for installation has been verified. Relocate, reshape and add rods, inserts or dowels as requested by the Engineer.
5. Installation shall be in accordance with the latest ICC Evaluation Service Report and the anchor manufacturer's instructions.
6. Drilling Holes:
 - a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by the Engineer.
 - b. Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device when required.
7. Hole Drilling Equipment:
 - a. Electric or pneumatic rotary type with medium or light impact.
 - b. Drill Bits: Carbide-tipped in accordance with ANSI B212-15.
 - c. Hollow drills with flushing air systems are preferred. Air shall be free of oil, water, or other contaminants which will reduce bond.
 - d. Where edge distance is less than 4 inches, use lighter impact equipment to prevent cracking and spalling of the concrete during the drilling process.
8. Hole Diameter:
 - a. As recommended by adhesive anchor system manufacturer.

9. Install rods, inserts and dowels at locations as indicated on the Drawings and with the required depth and spacing.
10. Cleaning Holes:
 - a. Insert long air nozzle into hole and blow out loose dust. Use air which is free of oil, water, or other contaminants which will reduce bond.
 - b. Use a stiff bristle brush to vigorously brush hole to dislodge compacted drilling dust.
 - c. Repeat step a.
 - d. Repeat steps as required to remove drilling dust or other material which will reduce bond.
 - e. Holes shall be clean and dry for rods, inserts and dowels.
11. Cleaning rods, inserts and dowels:
 - a. Degrease over embedment length. Rods, inserts and dowels shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.
12. Minimum Embedment Depths (unless greater depth is noted on drawings):

a. All-threaded Rods:

| Anchor Diameter (inch) | Min. Embedment (inches) |
|---------------------------|----------------------------|
| 1/2 | 4 |
| 5/8 | 5 |
| 3/4 | 6 |
| 7/8 | 7 1/2 |
| 1 | 9 |

b. Inserts: Per manufacturer.

c. Dowels:

| Bar size | Min. Embedment (inches) |
|----------|----------------------------|
| #4 | 6 |
| #5 | 7 |
| #6 | 8 |
| #7 | 9 |

D. Expansion and Undercut Anchors:

1. Do not use expansion or undercut anchor to substitute for anchor bolt unless approved by the Engineer.
2. Accurately locate anchors and set perpendicular to surfaces from which they project.
3. Installation shall be in accordance with the latest ICC Evaluation Service Report and the anchor manufacturer's instructions.
4. Drilling Holes:
 - a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without approval by the Engineer.
 - b. Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device prior to drilling.
5. Hole Drilling Equipment: Use the following unless otherwise specified in the latest ICC Evaluation Service Report for the anchor and the manufacturer's instructions.
 - a. Drill: Electric or pneumatic rotary type with medium or light impact.
 - b. Drill Bits: Carbide-tipped in accordance with ANSI B212-15.
 - c. Hollow drills with flushing air systems are preferred. Air shall be free of oil, water, or other contaminants that will reduce bond.
 - d. Where edge distance is less than 4 inches, use lighter impact equipment to prevent micro-cracking and concrete spalls during drilling process.
 - e. Comply with the latest ICC Evaluation Service Report and the anchor manufacturer's instructions.
6. Installation shall be in accordance with the latest ICC Evaluation Service Report and the anchor manufacturer's instructions.

7. Minimum embedment depths (unless greater depth is recommended by manufacturer or noted on drawings):

a. Expansion Anchors:

| Anchor Diameter (inch) | Embedment Depth (inches) |
|---------------------------|-----------------------------|
| 3/8 | 2-1/2 |
| 1/2 | 3-7/8 |
| 5/8 | 5-1/8 |
| 3/4 | 5-3/4 |
| 1 | 9-3/4 |

b. Undercut Anchors:

| Anchor Diameter (mm) | Embedment Depth (mm) |
|-------------------------|-------------------------|
| 10 | 107 |
| 12 | 135 |
| 16 | 203 |

3.3 FIELD QUALITY CONTROL

- A. Contractor shall employ an independent Testing Laboratory to perform special inspections and testing of anchors.
- B. Inspections shall be done by a special inspector in accordance with Section 1704 of the 2019 CBC. Anchors post-installed in hardened concrete shall be inspected per Section 1705 of the CBC.
 - 1. Special inspector shall periodically inspect the work for conformance with the Specifications and Drawings, and shall record and report to the Engineer the following:
 - a. Product description including product name, expiration date, nominal size and grade of anchors and dowels, and embedment depth.
 - b. Hole description including verification of drill bit compliance with ANSI B212.15-1994, hole depth, and cleanliness.
 - c. Installation description, including verification of concrete type and compressive strength, and verification of anchor installation and location (spacing and edge distance) in accordance with Manufacturer’s published installation instructions and ICC-ES Report.

- C. Field Tension Tests for anchors and dowels by an independent Testing Laboratory.
1. Field test anchors and dowels in tension (proof load). Test adhesive system anchors after adhesive has cured. Proof loads depend on the characteristics of each anchor type including embedment, edge distance and concrete strength. In general the proof load shall be 1.1 times the design tensile strength (ϕN_n) per ACI 318-14 Chapter 17 and the current ICC-ES Report for the anchor or system used; however it shall not exceed 80% of the anchor yield strength nor 2/3 of the nominal concrete breakout strength. The test load shall be determined by the anchorage designer and verified by the Engineer after the anchors have been installed.
 2. Test at least 5% of each type and size of anchors and dowels, but no less than one (1) test of each anchor and dowel in each distinct area of work.
 3. Loads shall be applied with a calibrated hydraulic ram for a minimum of 10 minutes.
 4. Displacement of adhesive anchors and dowels shall not exceed $D/10$, where D is nominal anchor or dowel diameter.
 5. If any anchor or dowel fails to hold the test load or meet the above criteria, test additional 10% of each type and size of anchor or dowel that failed. If any additional failures occur, test all anchors of the type and size that failed.
 6. Reinstall all failed anchors and dowels, and test them as directed by the Engineer.
- D. Access for testing and Sample Dowels:
1. Examine concrete surfaces where dowels must be tension tested. When existing reinforcement is present, verify accessibility for tension test. Tension test dowels prior to placing surrounding new reinforcement.
 2. Where dowels are inaccessible for tension test, install sample dowels for testing at alternative similar locations as directed by the Engineer.
- E. Cost of special inspections, testing, sample dowels and reinstalled anchors and dowels, due to failure, shall be borne by Contractor.

3.4 REPAIR OF DEFECTIVE WORK

- A. Anchors and dowels that fail to meet installation torque requirements or proof load test shall be regarded as malfunctioning. Remove and replace misplaced or malfunctioning anchors. Fill empty anchor holes and patch failed anchor locations with non-shrink epoxy grout.

END OF SECTION

SECTION 06 70 13

FIBERGLASS REINFORCED PLASTIC FABRICATIONS IN ODOR TREATMENT EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies general requirements for fiberglass reinforced plastic (FRP) fabrications. Equipment-specific requirements are detailed in other sections of the contract documents pertaining to specific equipment. This section is intended to be used in conjunction with the other related equipment specification sections and design drawings. It is intended to specify materials, describe methods of work, and provide for documentation of quality and acceptance.

1.2 QUALITY ASSURANCE

- A. Quality, as represented by raw materials used, manufacturing practices employed, and condition of the finished product, is of prime importance. Knowledge of new technology in the interest of improved quality and/or lower cost is welcomed. However, any change of raw materials, alteration of construction, or other deviations from the requirements of the Specification sections or design drawings must be submitted in detail and approved in writing by the Engineer.

1.3 REFERENCES

- A. This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to the documents in this section 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, whether or not the document has been superseded by a version with a later date, discontinued or replaced.

| Reference | Title |
|---|--|
| AISC and Research Council for Riveted and Bolted Structural Joints (RCRBSJ) | Specification for Structural Joints Using ASTM A325 or A490 Bolts |
| American Institute of Steel Construction (AISC) | Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings |
| AMCA 500 D | Laboratory Methods of Testing Dampers for Rating |
| ASME/ANSI RTP-1 | Reinforced Thermoset Plastic Corrosion Resistant Equipment |
| ASTM C582 | Standard Specification for Contact Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment |
| ASTM D883 | Definitions of Terms Relating to Plastics |
| ASTM D2471 | Gel Time and Peak Exothermic Temperature of Reacting Thermoset Resins |
| ASTM D2563 | Recommended Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts |
| ASTM D2583 | Test for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor |
| ASTM D2584 | Ignition Loss of Cured Reinforced Resins |
| ASTM D3567 | Determining Dimensions of Reinforced Thermosetting Resin Pipe and Fittings |
| ASTM D3982 | Standard Specification for Contact Molded "Fiberglass" (Glass Fiber Reinforced Thermosetting Resin) Duct and Hood |
| ASTM E84 | Standard Method of Test for Surface Burning Characteristics of Building Materials |
| AWS D1.1, American Welding Society (AWS) | Structural Welding Code |
| Iron and Steel Society | Pocketbook of Standard Steels |
| IBC | International Building Code |
| IMC | International Mechanical Code |

1.4 DEFINITIONS

- A. The terminology of this specification is consistent with ASTM D883. Fabricators are responsible for correct interpretation. Further definitions are as follows:
1. **Equipment:** The FRP equipment, as listed in the pertinent equipment sections, including all vessels, ancillary equipment, work, and materials as described in this section and related sections.
 2. **Fabricator:** The primary party responsible for fabrication of the FRP equipment.
 3. **Field Joining Contractor:** The party responsible for the field joining of the equipment. This may be the same party as the Fabricator and/or the Contractor.
 4. **Mat:** A fibrous material consisting of randomly oriented chopped or swirled glass filaments loosely held together with a binder.

5. Chopped Glass: A fibrous material consisting of randomly oriented chopped filaments applied directly to a mold surface or laminate under construction by a chopper gun.
6. Fiber Prominence (Jackstraw): The distinct visibility of individual glass strands causing a loss of translucency of the laminate.

1.5 SUBMITTALS

- A. Submittals shall be provided in accordance with Specification Section 01 33 00. Submittal requirements for FRP fabrications are detailed in those specification sections pertaining to specific equipment.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All products shall be new, of current design, and produced by approved manufacturers who specialized in the fabrication of such products.
- B. Stainless steel hardware and fabricated parts (including anchor bolts, anchor lugs, lifting lugs, hangers, etc.) shall be AISI Type 316.
- C. Gaskets for use with FRP flanges shall be flat, full-faced, and drilled to match the drilling of the mating flange(s). Gasket material shall be as specified in the pertinent equipment section.

2.2 MATERIALS

- A. Resin:
 1. The equipment shall be fabricated using the corrosion-resistant resin(s) specified in the pertinent equipment section, or equal as approved by the Engineer. The resin shall be used throughout all laminates.
 2. Catalysts and promoters shall be of the type and amount recommended by the resin manufacturer for use with their resin in the required service. The Engineer will review the Fabricator's choice of resin/catalyst before fabrication begins to verify compliance to the resin manufacturer's recommended procedures. Positive measurement control of catalysts, promoters, and resins shall be maintained at all times.
 3. No fillers, additives, or pigments shall be employed in the resin except as specified below, and in the pertinent equipment section. A thixotropic agent for viscosity control may be used in the proportion and type recommended by the resin manufacturer as approved by the Engineer. No thixotropic agent is to be used in the corrosion liner or on surfaces to be in contact with the corrosive environment.

4. Resin putty shall be made using the same resin as was used in the original fabrication of the parts to be joined. Resin putty shall contain a minimum 15 percent by weight of milled glass fibers. A fumed-silica additive such as Aerosil 200 or Cab-O-Sil TS-720 shall be added to increase the viscosity of the putty. The use of silica flour, grinding dust, or other fillers is not allowed.
5. When specified in the pertinent equipment section, antimony trioxide or antimony pentoxide shall be added to the resin in the amount necessary to achieve the required fire retardancy rating in the structural wall only. Resin manufacturer's recommendations shall be followed. The corrosion liner shall not contain this additive.

B. Reinforcement:

1. Type and sequence of reinforcement to be used shall be as designated in the pertinent equipment section, the construction details, or on the design drawings.
2. Glass fiber reinforcement used shall be a commercial grade corrosion-resistant borosilicate glass, except as otherwise noted.
3. All glass fiber reinforcing shall have an epoxy compatible silane type surface finish and binder that is specifically recommended by the glass manufacturer for the particular resin system to be used. This surface finish should allow the maximum possible chemical bonding between the resin and glass.
4. Surfacing veils shall be Type C (chemical grade) glass, 10 mil thickness, unless otherwise specified. An apertured polyester surfacing veil, such as Nexus or approved equal, shall be used only when indicated in the pertinent equipment section.
5. Mat shall be Type E (electrical grade) glass, 1-1/2 oz. or 3/4 oz. per sq. ft., with nominal fiber length of 1.25 ± 0.75 inches.
6. Continuous glass roving used in chopper guns for spray-up shall be Type E chopper roving.
7. Woven roving shall be 24 oz. per sq. yd. Type E glass and have a 5 x 4 plain weave.
8. Continuous roving used in filament wound construction shall be Type E glass winder roving with a yield of 200 yards or more per pound.
9. Unidirectional fabric shall be a weft style made with glass strand of a yield equal to or greater than, (more yds./lb) that of the adjacent filament winding strand, stitched in a manner that provides uniform strand density without bunching or gapping.

2.3 FABRICATION

A. Molds:

1. Molds constructed of Masonite, wood, or other porous material must be completely covered with Mylar or other suitable material to produce a smooth and glossy inner surface on the FRP equipment.
2. Molds and mandrels shall be hard-surfaced such that working the wet laminate will not cause local displacement of the material or air entrapment. Covering of mandrels with cardboard is not acceptable. If submitted, Contractor shall demonstrate that it produces an RTP-1 Level 2 liner quality before being approved by the Engineer prior to start of fabrication.
3. Certain components shown on the design drawings assume the availability of specific tooling and/or molds. Alternate mold configurations may be considered by the Engineer in the interest of cost savings or betterment. Any deviations from the dimensions shown on the design drawings must be approved by the Engineer prior to the start of fabrication.

B. Vessel Assembly:

1. All cutouts from the equipment are to be marked, indicating their original location, and retained. All cutouts become the property of the Engineer.
2. Centerlines marked on the equipment for use in assembly shall not be removed until after inspection by the Engineer.
3. Flanged nozzles shall be installed with bolt holes straddling principle centerlines of the vessel. For tank tops, nozzle bolt holes straddle radial centerlines. Other layouts take precedence when detailed on the design drawings.
4. When requested, Fabricator shall supply to the Contractor, at the earliest possible time, a template which locates anchor bolt holes within $\pm 1/8$ -inch for each vessel.
5. When specified or indicated on the design drawings or construction details of the pertinent equipment section, a non-skid surface shall be provided on the exterior surface of domed covers. Silica grit may be applied in conjunction with the final resin coat, or other methods employed if approved by the Engineer.

6. The Fabricator shall furnish and overlay on the outside of the equipment a plastic nameplate showing the following information:
 - a. Name of manufacturer
 - b. Date of manufacture
 - c. Engineer's purchase order number
 - d. Equipment name/number
 - e. Resin number and manufacturer
 - f. Design pressure and temperature
 - g. Vessel diameter, height, and weight
7. Butt joints or shell joints are to be in the number and location(s) as shown on the design drawings. Additional joints are not allowed except as approved by the Engineer. Slip joints, "mod joints," or other methods not conforming to the design drawings are not allowed. If joint locations are not indicated on the design drawings, Fabricator shall propose number and location for approval by Engineer.
8. Allowable tolerances shall be as listed in RTP-1, Fig. 4-1 and NM 7-1, except as modified herein or on the design drawings. Laminate thicknesses designated on the design drawings or in the approved Design Submittal are construction minimums.
9. When joining components, gaps at mating edges shall be limited to 1/4-inch maximum, and misalignment of inside surfaces shall not exceed 1/3 of the lesser wall thickness.
10. The outside surface of vessel flat bottoms after assembly shall be flat within $\pm 1/2$ -inch. In addition, localized indentations or protrusions shall not exceed $\pm 1/4$ -inch within two feet.
11. Nozzle cutout reinforcement shall be applied as required by the approved Design Submittal.
12. When reinforcing materials are cut to facilitate placement around an installed nozzle or opening, joints in successive reinforcing layers shall be staggered to avoid overlapping and shall not be placed so that the joints are parallel to the axis of the tank. The principal fiber direction of the woven roving reinforcement shall be parallel to the tank axis.

C. Ductwork Assembly:

1. Centerlines marked on the equipment for use in assembly shall not be removed until after inspection by the Engineer.
2. Fabricator shall apply and overlay an identification tag on each duct spool, straight duct length or other equipment, showing the following information:
 - a. Name of manufacturer
 - b. Date of manufacture
 - c. Contractor's purchase order number
 - d. Resin identification
 - e. Duct diameter
 - f. Laminate thickness
 - g. Unique spool identification number
3. Tolerances on spool assembly shall be as follows, except as otherwise noted on the drawings:
 - a. Diametral, including out of roundness, shall be $\pm 1/8$ -inch or ± 1 percent, whichever is greater.
 - b. Tolerance on overall length and location of tees and laterals shall be $\pm 1/4$ -inch.
 - c. Plain ends shall be cut square with the duct axis $\pm 1/8$ -inch.
 - d. Flanges shall be perpendicular to the axis of the duct within $1/2$ degree and shall be flat to $\pm 1/32$ -inch up to and including 16-inch diameter and $\pm 1/16$ -inch for larger diameters.
 - e. Tolerance on the specified angle for tees, laterals, and miters shall be $\pm 1/2$ degree.
4. All cutouts from the equipment are to be marked, indicating their original location, and retained. All cutouts become the property of the Engineer.
5. Cut Lengths: Engineer prefers straight duct to be supplied to required lengths with a minimum of shop butt joining of shorter lengths. Recognizing that waste can be minimized by joining shorter sections, or that mandrels may be limited to 20 ft., shop butt joints will be allowed within reason.

6. Duct Marking: All lengths of duct shall be identified in accordance with the requirements of paragraph 2.3.C Ductwork Assembly. If required by the Engineer, Fabricator shall return a marked-up copy of the layout drawings, with Mark numbers referenced.

D. Piping Assembly:

1. Fabricator is responsible for field verification of required piping spool dimensions to assure proper fit-up. Provide field trim as required to allow adjustment during installation.
2. Centerlines marked on the piping for use in assembly shall not be removed until after inspection by the Engineer.
3. Fabricator shall apply and overlay an identification tag on each piping spool, straight length or component, showing the following information:
 - a. Name of manufacturer
 - b. Date of manufacture
 - c. Contractor's purchase order number
 - d. Resin identification
 - e. Pipe diameter
 - f. Laminate thickness
 - g. Unique spool identification number
4. Tolerances on piping spool assembly shall be as follows, except as otherwise noted on the drawings:
 - a. Diametral, including out of roundness, shall be $\pm 1/8$ -inch or ± 1 percent, whichever is greater.
 - b. Tolerance on overall length and location of tees and laterals shall be $\pm 1/8$ -inch.
 - c. Tolerance on lengths including field trim shall be ± 1 inch.
 - d. Plain ends shall be cut square with the pipe axis $\pm 1/8$ -inch.
 - e. Flanges shall be perpendicular to the axis of the duct within $1/2$ degree and shall be flat to $\pm 1/32$ -inch up to and including 16-inch diameter and $\pm 1/16$ -inch for larger diameters.
 - f. Tolerance on the specified angle for tees, laterals, and miters shall be $+1/2$ degree.

5. All cutouts from the equipment are to be marked, indicating their original location, and retained. All cutouts become the property of the Engineer.

E. All Laminates:

1. Refer to the approved Design Submittal for reinforcement sequences. No deviations in number or sequence of plies will be allowed without approval by the Engineer.
2. Positive methods shall be used to assure uniform total thickness of the laminate and uniform glass-to-resin ratio without surplus resin or unsaturated glass.
3. All laminate thicknesses shown on the approved Design Submittal are construction minimums. It is the responsibility of the Fabricator to verify that minimum thicknesses are obtained using the laminate sequences specified.
4. The minimum allowable structural laminate thickness shall be the total laminate thickness less the specified sacrificial corrosion liner thickness.
5. Delays in hand lay-up laminating sequences for purposes of exotherm shall follow application of a mat ply. When lamination is resumed, it shall begin with a mat ply. Additional mat layers applied due to exotherm stops shall not be considered as part of the required wall thickness.
6. Laminating sequence interruptions shall not exceed 24 hours, and the in-process surface must retain acetone sensitivity until laminating is resumed. Lack of compliance with these procedures, or any indication that contamination of the surface has occurred, shall require that surface preparation be accomplished before resuming. Before resuming lamination, any rough areas or projections shall be touch-ground to allow full contact of the succeeding wet laminate.
7. An exotherm interruption is specifically prohibited within the corrosion liner. An exotherm interruption between the corrosion liner and the structural layers is limited to a maximum of twelve hours.
8. Chopped strand glass applied by chopper gun is allowed in lieu of mat layers if the application is mechanically controlled in a manner that ensures uniform thickness and glass-to-resin ratio. The specific methodology must be approved by the Engineer prior to fabrication.
9. All non-mold surfaces shall be coated with resin containing wax additive in the amount necessary to allow full cure of the surface. In the case of interior primary corrosion surfaces, such as interior overlays, this wax coat shall be applied within 24 hours of original lamination. In the case of exterior surfaces, this wax coat shall also contain a UV stabilizer in the type and amount recommended by the resin manufacturer.

10. The exterior surface of all equipment shall be resin rich and reinforced with one layer C-glass surfacing veil, except as otherwise specified.
11. When specified in the pertinent equipment section or on design drawings, the exterior coat shall be an opaque pigmented surface coat, applied only after Engineer inspection. Color to be selected by the Engineer.
12. Saturation of reinforcement prior to application to equipment shall not be performed on waxed paper or other contaminated material. Saturation of reinforcement on clean paper or cardboard is allowed.
13. All cut edges shall be thoroughly coated with resin so that no glass fibers are exposed. Cut edges exposed to the corrosive service shall be sealed with a corrosion liner laminate. All voids shall be filled with resin putty.

F. Corrosion Liner Laminates (inner surface and interior layers):

1. The inner (corrosion service) surface of all laminates shall be resin-rich and reinforced with surfacing veil of the type and number of layers as described in the pertinent equipment section or on design drawings.
2. The interior layer of the corrosion liner shall consist of 1-1/2 oz. per sq. ft. mat in the number of layers specified in the pertinent equipment section or on design drawings. Each ply shall be rolled separately to remove entrapped air.
3. All plies of the inner surface and interior layer are to gel completely before proceeding with the structural laminates, but in no case shall the interruption exceed twelve hours. The surface must retain acetone sensitivity until the structural laminate is applied. Lack of compliance to either of these aspects shall be cause for rejection of the corrosion liner.
4. Completed corrosion liner, as described above, shall contain not less than 20 percent nor more than 30 percent glass (by weight). No thixotropic material shall be used in the liner resin or in the fabrication of any FRP components intended for direct contact with the process stream. Completed liner shall be the minimum thickness specified in the pertinent equipment section or on design drawings. Completed liner shall meet visual defects requirements of RTP-1, Table 6-1, Level 2.
5. All edges of surfacing veils in wet lay-up shall be lapped a minimum of one inch.
6. A separately cured unreinforced gel coat shall not be used.
7. Antimony shall not be used in the corrosion liner.

G. Hand-Layup Structural Laminates:

1. The corrosion liner laminate shall be followed by structural laminates of varying construction types, as specified in the pertinent equipment sections, or on the design drawings.
2. For hand-layup structural laminates, reinforcement shall consist of mat and woven roving in the sequence specified in the pertinent equipment section or on design drawings.
3. All woven roving shall have a ply of mat on each side. Two adjacent plies of woven roving are not permitted.
4. All edges of woven roving material in wet lay-up shall be lapped a minimum of two inches. Lapped edges of adjacent layers shall be staggered to obtain the maximum possible strength.
5. Laminates containing primarily 1-1/2 oz. per sq. ft. mat layers in conjunction with woven roving shall contain not less than 35 percent or more than 45 percent glass (by weight).
6. Laminates containing primarily 3/4 oz. per sq. ft. mat layers in conjunction with woven roving are considered to be high strength laminates and shall contain not less than 45 percent or more than 55 percent glass (by weight).

H. Filament Wound Structural Laminates:

1. The corrosion liner laminate shall be followed by structural laminates of varying construction types, as specified in the pertinent equipment section, or on the design drawings.
2. For filament wound structural laminates, reinforcement shall consist of continuous strand fiberglass roving applied with a minimum of interruptions until the specified minimum thickness is attained. This laminate shall contain the percentage of glass (by weight) specified in the Design Submittal.
3. Each complete cycle of filament winding shall form a closed pattern of winding bands which completely covers the surface with two bi-directional layers. Each layer shall be a maximum of one roving in thickness. Singular cycles shall not exceed a thickness of 0.06 inches. In laminates with helix angles greater than 75 degrees, a minimum of 10% of the structural wall thickness shall be oriented at 0 degrees (longitudinal direction), plus or minus 5 degrees. Unidirectional roving shall be a minimum of 15 oz./sq. yd. and applied in a minimum of two layers. Unidirectional layers shall be evenly distributed through the thickness, with the first layer applied immediately after the first cycle of winding and the last layer located immediately prior to the last cycle of winding.

4. Upon request, Fabricator shall submit the following information:
 - a. Specific glass strand to be used and yield
 - b. Net thickness per cycle
 - c. Number of strands per inch in the winding band
 - d. Typical glass-to-resin ratio
5. Spacing of filaments within the winding band shall be sufficiently close that bridging is avoided, and glass content is maintained within the specified limits. Spacing of the filaments shall be uniform across the winding band without bunching or gapping.
6. The helix angle of winding shall be as specified in the approved Design Submittal, as measured from the centerline of revolution of the equipment shell.
7. Tolerance on helix angle is +2 degrees, -2 degrees, unless otherwise noted in the pertinent equipment sections.
8. If layers of mat or chopped glass are needed to ensure proper bonding between the corrosion liner and filament winding, or within the filament winding to accommodate the fabricator's manufacturing methods, or to provide for laminates of acceptable quality, they may be added at the Fabricator's option. These layers are considered to be extra material and will result in a thickness greater than specified. The amount of filament winding and unidirectional roving specified required by the approved Design Submittal must still be applied.
9. If for any reason, winding is interrupted to the point where the outer surface is gelled or exotherm temperatures are excessive, production shall stop and the laminate shall be allowed to cure. Any prominent ridges left on the cured surface shall be ground to smooth the projections and prevent bridging. Following the grinding, a bedding layer of 3/4 oz. per sq. ft. mat or chopped glass shall be applied and thoroughly rolled to remove air. Winding with continuous strand may be resumed before this layer gels. The additional mat layer is extra material and will result in a wall thickness greater than that specified.

I. Surface Preparation:

1. Surface Abrasion:
 - a. Prior to starting secondary overlays, adequate surface abrasion with no surface contamination is required. Every precaution shall be taken to assure adequate surface preparation and a good bond of the secondary overlays.

- b. Prior to making all overlays, the cured or wax coated surfaces of the area to be overlaid must be roughened thoroughly by grinding. The roughened area shall extend 1-inch minimum beyond the proposed overlay edge. The roughened area must be completely coated with wax coat at the completion of the joint.
- c. Grinding shall be sufficiently deep that all traces of glossy resin coat are removed, and that glass fiber is exposed over the entire abraded surface.
- d. The edges of the abraded surface shall be "feathered" out such that no sharp discontinuities exist.
- e. For surface abrasion by grinding, grinding disks shall be new and not contaminated, with a grit size of 16 to 24.
- f. FRP joint application must begin within four hours of surface abrasion, or else abrasion must be repeated.

2. Final Surface Preparation:

- a. Within 15 minutes prior to beginning FRP joint application, dust shall be removed from the abraded area by vacuuming or brushing with clean non-metallic brushes or wiping with clean dry rags.
- b. Solvent wiping the abraded area is not allowed.
- c. Air blowing the abraded area is not allowed.
- d. If any indication of contamination is present after this final surface preparation, the abraded area shall be scrubbed with solvent and allowed to evaporate to verify removal of the contaminant. Repeat this solvent wash if necessary. Surface abrasion must be repeated after solvent washing.

J. Joining Laminates:

1. FRP joining laminates are subject to all applicable requirements specified in other sections for laminates.
2. FRP joints shall be reinforced with an overlay of glass reinforcement and resin which extends equally within $\pm 1/2$ -inch on each side of the joint. A smooth contour is required. Minimum thickness, ply sequence, and ply widths of FRP joints shall be as specified in the approved Design Submittal.
3. Tolerance on width of joint reinforcement plies is +1-inch, -0 inch. Woven roving plies shall not exceed the width of the mat ply below them.

4. Parts to be joined shall be restrained to prevent movement until completion and cure of the joint overlay.
5. Parts shall be fit-up, and it shall be verified that all tolerances and assembly requirements of sections are satisfied. All cut edges shall be resin coated. The void between component parts shall be completely filled with resin putty, taking care not to extrude an excessive amount of putty into the interior.
6. The puttied area shall be ground to a smooth contour and final surface preparation repeated.
7. The abraded area to be overlaid shall be resin coated immediately prior to applying glass reinforcement, using a stiff brush to work resin into the rough surface. The resin coat shall be applied only to an area as wide (+1-inch, -0 inch) as the next exotherm stage of the joint sequence and shall be repeated prior to each exotherm stage. No thixotropic material shall be used in this resin.

K. Environment:

1. It is the Fabricator's responsibility to maintain conditions in the FRP laminate work area during all times when the final surface preparation and FRP laminate application are in process in order to not jeopardize the reliability of the laminate or secondary bond. As a minimum, controls shall include the following.
 - a. All surfaces to be overlaid and all materials are to be maintained within a range of 60 to 95 degrees F. This temperature must also be at least 5 degrees F greater than the dew point. During the exotherm stage(s) of each laminate sequence, and during any unplanned exotherms, the temperature of the curing laminate will likely exceed 95 degrees F. No further lamination may proceed until the exotherm has completed and the laminate has cooled to 95 degrees F or less. No attempt shall be made to cool the curing laminate prematurely.
 - b. Prepared surfaces and materials shall be protected from blowing dust, moisture, and other contaminants.
 - c. If any of the above conditions are violated while the final surface preparation or FRP laminate application are in-process, work shall stop immediately, and the process must begin again with surface abrasion.
 - d. Materials shall be stored in a dry area and within the temperature and humidity limits recommended by the manufacturers.

L. Flanges:

1. Except as otherwise specified on the design drawings, flanges shall be made by hand-layup construction with nozzle neck and flange made integrally in one piece and fabricated in accordance with the dimensions shown on the design drawings. All layers of reinforcement in the nozzle neck and hub shall extend uninterrupted into the flange.
2. Unless otherwise noted on the design drawings, additional hub thickness shall be built-up using alternating layers of 1-1/2 oz. per sq. ft. mat and 24 oz. per sq. yd. woven roving.
3. Additional thickness in the flange shall be built-up using "ring" cutouts of mat, evenly distributed throughout the flange thickness.
4. Press molded or filament wound flanges are not allowed. Filament winding of the nozzle neck is not allowed, and the "flange on pipe" method of nozzle fabrication (Ref. RTP-1, Fig. 4-11) is not allowed.
5. To obtain proper seating, bolt holes shall be spotfaced for SAE size washers. Overall machine facing of the back of flanges is not permitted if the fillet radius is maintained and the hub thickness is not undercut. Bolt holes and all other cut surfaces shall be resin coated. Spotfacing shall not produce a flange thickness less than that specified in the pertinent equipment section or on the design drawings.
6. Bolt holes in flanges are to straddle principal centerlines of the equipment. Tolerance in bolt hole locations and in diameter of bolt circle shall be $\pm 1/16$ -inch.
7. Flange faces shall be flat to $\pm 1/32$ -inch up to and including 16-inch diameter and $\pm 1/16$ -inch for larger diameters.
8. Resin coat all flange bolt holes so that no fibers are exposed.

2.4 FABRICATION QUALITY CONTROL

A. Allowable Visual Defects:

1. Fabricator shall take care to minimize the amount of defects in all laminates. In no case shall visual defects in any area of the equipment exceed the maximum allowable levels of visual defects set forth in RTP-1, Table 6-1, Level 2.

2. Air entrapment limits, (gaseous bubbles or blisters), that are required to supplement RTP-1 Table 6-1, shall be as follows. Dimensions refer to the largest measured dimension for any specific defect. Defects at the interfaces between layers are subject to the most stringent requirement.
 - a. Inner Surface: 2 per sq. in. up to max. size of 1/16", except < 1/64" is unlimited.
 - b. Interior Layer: 2 per sq. in. up to max. size of 1/8", except < 1/32" is unlimited.
 - c. Structural Layer: 2 per sq. in. up to max. size of 1/4", except < 1/8" is unlimited.
3. Presence of visual defects in excess of the allowable levels shall be grounds for rejection of the equipment.

B. FRP Fabrication:

1. Fabricator shall be responsible for implementation of a comprehensive quality assurance procedure. The minimum requirements are described below.
 - a. Fabricator shall designate personnel to inspect equipment while in-process and after completion to assure compliance to all aspects of the specification and design drawings. Inspection shall include, as a minimum, checks for visual defects, laminate thickness and sequence, glass content, Barcol hardness, acetone sensitivity, dimensional tolerances, adherence to construction details, surface preparation, and environmental conditions. Fabricator's inspector shall complete a report of the findings including method of measurement for each separate assembly.
 - b. Prior to use of any resin, Fabricator shall test resin to establish cure characteristics and verify that it meets the resin manufacturer's acceptance standards.
 - c. Resin testing shall be performed in accordance with ASTM D2471. Gel time to peak exotherm and peak exotherm temperature shall be recorded.
 - d. If the Fabricator in any way alters the resin after receipt, such as through the addition of styrene, promoters, or other additives, one test shall be performed for each drum or portion thereof mixed with additives.

- e. Fabricator shall provide documentation for each test, including resin type, manufacturer, batch and lot number, drum number, complete listing of all additives with amounts added, and description and manufacturer of each additive.
 - f. Fabricator shall inspect all glass reinforcement prior to use in fabrication and shall not use any glass that does not meet the manufacturer's acceptance standards. Glass material that is wet or has been wet shall not be used. For each type of glass and lot number used, Fabricator shall record the manufacturer, product description, binder type, product code, production date, and lot number. For mat, woven roving, unidirectional roving, and cloth, records shall also include actual measured weight per square yard of material.
 - g. Fabricator shall retain all nozzle cutouts and other excess laminate, clearly marking each piece to identify its original location. These laminate samples become the property of the Engineer. For areas where valid laminate samples are not available, sample plugs shall be taken at the Engineer's request. Repair of subsequent holes will be performed in a manner approved by the Engineer.
 - h. Fabricator shall verify glass content of corrosion liner and structural laminate on samples from at least two representative areas of each major component in accordance with ASTM D2584. This test shall be completed, and the results reported as follows:
 - 1) Measure and record total thickness, corrosion liner thickness and structural laminate thickness.
 - 2) Separate the corrosion liner from the structural laminate and determine glass content for each per ASTM D2584.
 - 3) Record the sequence of individual reinforcement plies from the remains of the ignition test.
 - i. Glass content of corrosion liner portion of laminates shall be within the range specified in paragraph 2.3.F Corrosion Liner Laminates. Minimum glass content of structural layers shall satisfy the minimum glass content used as a basis for the physical properties used in the approved Design Submittal.
2. Prior to final shipment of the equipment, Fabricator shall provide the Engineer with a complete quality control report, consisting of copies of all records maintained for compliance with this section.

C. Engineer's Inspection:

1. The Engineer shall be permitted access to the equipment during fabrication and upon completion for the purpose of verifying compliance to the contract documents. The Engineer's inspection is not intended to replace the Fabricator's own quality control procedures.
2. In no respect does inspection of any equipment by the Engineer relieve the Fabricator of compliance with the contract documents. A final inspection shall be performed by the Engineer when the Fabricator certifies that all the terms and requirements of the contract documents have been satisfied. At least five days notice shall be given the Engineer prior to this inspection.
3. The Fabricator is required to notify the Engineer at the completion of particular milestones during fabrication. The Fabricator shall give at least 48 hours notice prior to occurrence of these milestones, as follows:
 - a. View tooling prior to fabrication
 - b. Beginning application of corrosion liner for each part
 - c. Extraction of each part prior to beginning assembly
 - d. Upon completion of each separate assembly
4. Engineer reserves the right to include additional milestones.
5. In the event the equipment is not to the stage of completion designated for a milestone inspection or is not complete as required for a final inspection at the time specified by the Fabricator, the Fabricator agrees to assume the cost of the inspector's time and expenses and further agrees that such charges be deducted from the cost of the equipment.
6. Engineer shall be allowed to photograph the equipment while in-process and/or upon completion.
7. Engineer retains the right to employ the use of magnification or other special viewing or measurement devices during inspection.
8. At the time of final inspection, the Fabricator shall assure that the equipment is cleaned of all foreign material and workings which might block the view of the Engineer. The equipment shall be in a position that allows for easy access and viewing and, at the request of the Engineer, shall be moved to allow viewing of all parts of the equipment.
9. Evidence of poor workmanship or lack of compliance with any aspect of the contract documents will be grounds for rejection of the equipment.

10. Subsequent repair of rejected equipment may, at the Engineer's option, be undertaken in an attempt to bring the equipment to an acceptable state. Repair procedures must be approved by the Engineer prior to implementation.

D. Engineer's Acceptance:

1. The Engineer may employ destructive testing, such as ultimate tensile or flexural strength tests or glass content ignition tests, on available samples or use other non-destructive test methods, such as acoustic emission or ultrasonic magnetic thickness measurement, on the completed equipment for verification of compliance to the contract documents.
2. Testing performed by the Engineer shall be accomplished through use of applicable ASTM test methods when appropriate.
3. Hardness tests shall be made for acceptance by the Engineer on the liner surface using the Barcol impressor, Model GYZJ 934-1, calibrated at two points in accordance with ASTM D2583. Ten readings will be taken in a localized area, deleting the two highest and two lowest, and averaging the remaining six. Minimum acceptable Barcol hardness will be a reading of 30, unless otherwise specified in the pertinent equipment section.
4. An acetone sensitivity test shall also be performed by the Engineer as an acceptance criterion. Evidence of a sticky or tacky surface following rubbing with an acetone-saturated cloth shall be grounds for rejection of the equipment.

2.5 SHIPPING

A. Equipment:

1. The Fabricator shall be responsible for proper packaging, loading, and protection of all materials to prevent transit and handling damage.
2. All equipment which is shipped in a horizontal position shall be mounted on padded cradles contacting at least 120 degrees of the vessel circumference. All end blocking used to prevent shifting of equipment must be padded.
3. Equipment shall be loaded with a minimum clearance of two inches between pieces (including external fittings, nozzles, or other projections) and the bed of the car or truck. When two or more units are shipped together, sufficient clearance shall be provided between units to prevent contact in transit.
4. Flange faces shall be protected by coverings of suitable plywood or hardboard, securely fastened.

5. Loose parts such as fasteners, gaskets, and accessory fittings shall be packaged securely to allow storage under field conditions.
6. All dry FRP field joining materials shall be precut in the shop and layered in order of laminate sequence, then labeled and packaged in sealed, moisture-proof containers for shipment.
7. When a number of loose items or field joining materials are packed in larger shipping crates, each crate will be individually marked or tagged as to its contents, clearly listing number and type of each item contained therein.

B. Ductwork and Piping:

1. The Fabricator shall be responsible for proper packaging, loading, and protection of all materials to prevent transit and handling damage.
2. All ducts and pipes shall be supported for shipment on cradles spaced no greater than 20 feet. Lengths shall also be supported by cradles within two feet of the end.
3. Cradles used to support duct, pipe, or other equipment during shall contact at least 120 degrees of the circumference, be padded and match the outside diameter within +1/8-inch, -0 inch.
4. If duct or pipe is stacked in layers, cradles shall be used which support each independently from the overlying and underlying equipment, such that no duct or pipe in a cradle carries more than its own weight.
5. Duct or pipe ends, and flange faces shall be protected by covering with suitable material which is securely fastened.
6. Equipment shall be loaded with a minimum clearance of two inches between pieces (including external fittings, nozzles, or other projections) and the bed of the car or truck.
7. Loose parts such as fasteners, gaskets, and accessory fittings shall be packaged securely to allow storage under field conditions.
8. When a number of loose items are packed in larger shipping containers, each container will be individually marked or tagged as to its contents, clearly listing number and type of each item contained therein.

2.6 HANDLING FRP EQUIPMENT

- A. The equipment shall not be rolled, slid, dropped, allowed to swing into other objects, or forced out of shape. Resulting impact and excessive distortions may cause cracking or crazing.

- B. When working in or around FRP equipment, care should be exercised to prevent tools, scaffolding, or other objects from striking or being dropped on or inside the equipment. Soft-soled shoes should be worn by workers entering the equipment.
- C. Proper rigging and hoisting practices shall be observed at all times.
- D. The use of a crane is recommended both in lifting and positioning the equipment. Ideally, the slings or cables attached to the equipment should lift as nearly vertical as possible and shall under no circumstances shall slings or cables lift more than 45 degrees from vertical. A spreader bar (lifting fixture) may be necessary to keep the lifting angle within this range.
- E. Lifting lugs in most cases are not designed to accommodate lifting vessels in or from the horizontal position. Nylon slings encircling the tank should be used for this purpose and for righting the vessel to the vertical position.
- F. Unless otherwise specified, use all lifting lugs, loaded uniformly for lifting vessels in the vertical position. The use of spreader bars is recommended to keep loads on lugs as nearly vertical and uniform as possible.
- G. When lifting lugs are not provided, and it is necessary to use lifting slings in direct contact with the FRP equipment, the slings shall be woven nylon or canvas at least 3 inches wide. Care must be taken to assure that shackles, eyes, hooks, or other objects do not come into contact with the FRP equipment.
- H. Do not attach lifting slings or cables to (nor allow them to come in contact with) any nozzles, flanges, gussets, or fittings other than lifting and/or anchor lugs.

PART 3 - EXECUTION

3.1 GENERAL

- A. FRP specialties shall be shipped, installed, joined and erected under the direction of factory-trained specialists. Where jointing is required, workers employed for these efforts shall have been trained in proper jointing techniques by the Fabricator. Fabricated equipment shall have the warning, "Plastic Equipment Handle with Care" stenciled on two sides in letters a minimum of 2 inches high.

3.2 ASSEMBLY AND ERECTION PLANS

- A. Prior to assembly and erection of FRP towers, tanks, stacks and similar structures, the Contractor shall provide assembly and erection plans prepared by the Fabricator. The plans shall provide details on handling, field connections and final installation.

3.3 PIPING INSTALLATION

A. Flanged Connections:

1. Flanged connections shall be aligned with the mating flange prior to tightening bolts. Do not use bolts to correct angularity or to close gaps.
2. FRP full face flanges shall be bolted only to full-faced mating flanges; mating to raised face or Vanstone flanges is not allowed.
3. Bolt threads shall be clean and lubricated to attain proper torque.
4. Use lubricated washers at both nut and bolt heads to protect back flange facing.
5. All flange bolts shall be final tightened with a torque wrench.
6. Tighten bolts alternately on opposite sides of the bolting pattern. Torque all bolts to 50% of intended torque and then repeat pattern to 100% of intended torque values.
7. After all bolts have been tightened to the intended torque, recheck the torque on each bolt in the same sequence, since previously tightened bolts may have relaxed.
8. Recommended maximum bolt torques are as follows. These values may be exceeded only with Fabricator's approval.

| Bolt Diameter | Torque (ft-lb) |
|---------------|----------------|
| 5/8" | 25 |
| 3/4" | 45 |
| 7/8" | 75 |
| 1" | 115 |
| 1-1/8" | 160 |
| 1-1/4" | 220 |

B. Field Joining:

1. Field joining shall be performed in accordance with this Section and the design drawings. Use of other joint designs is prohibited.
2. The Field Joining Contractor shall have experience in the joining of FRP piping using the methods described in this Section and shall be able to demonstrate ability to perform the required work to the satisfaction of the Engineer.

3. Field Joining Contractor shall be responsible for the disposal of waste material resulting from field joining and associated work. Disposal of waste material shall conform to all applicable local regulations, as well as disposal and safety practices of the installation site.

END OF SECTION

SECTION 09 90 00

PAINTING AND COATINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included:

1. Surface preparation, furnishing, and application of paint and special protective coatings, complete.
2. The Contractor shall perform all painting and coatings work in accordance with applicable local, state and federal requirements.
3. Refer to Article 2.2 – PAINTING AND COATING SYSTEMS for a list of coating systems and Article 3.3 – COATING SYSTEM APPLICATION SCHEDULE for the locations where they are to be applied.

B. Related Sections

1. Section 05 45 13 – Mechanical Metal Supports.
2. Section 05 50 00 – Metal Fabrications.
3. Section 09 96 56.05 – High Build Epoxy Coating System on Concrete.
4. Section 22 05 53.05 – Pipe Identification.
5. Division 33 – Utilities
6. Division 40 – Process Integration.

1.2 ABBREVIATIONS

| | |
|--------|---|
| ANSI | American National Standards Institute |
| AWWA | American Water Works Association |
| CSP | Concrete Surface Profile |
| FRP | Fiberglass Reinforced Plastic |
| HC 1 | Hydrochloric Acid |
| ICRI | International Concrete Repair Institute |
| MC | Methylene Chloride |
| MDFT | Minimum Dry Film Thickness |
| MDFTPC | Minimum Dry Film Thickness Per Coat |
| mil | Thousandths of an Inch |
| MIL-P | Military Specification – Paint |
| NACE | National Association of Corrosion Engineers |

| | |
|--------|------------------------------------|
| NSF | National Sanitation Foundation |
| OSHA | Occupational Safety and Health Act |
| PSDS | Paint System Data Sheet |
| PVC | Polyvinyl Chloride |
| SFPG | Square Feet Per Gallon |
| PVDF | Polyvinylidene Fluoride |
| SFPGPC | Square Feet Per Gallon Per Coat |
| SP | Surface Preparation |
| SSPC | Steel Structures Painting Council |

1.3 REFERENCES

- A. American Society of Testing Materials (ASTM) standards.
- B. International Concrete Repair Institute (ICRI) standards
 - 1. ICRI 310.2 Selecting and Specifying Concrete Surface Preparation.
- C. Steel Structures Painting Council (SSPC)
 - 1. SSPC Vol. 1, Steel Structures Painting Manual, Volume 1, Good Painting Practice.
 - 2. SSPC Vol. 2, Steel Structures Painting Manual, Volume 2, Systems and Specifications.
 - 3. SSPC-SP 1 Solvent Cleaning.
 - 4. SSPC-SP 3 Power Tool Cleaning.
 - 5. SSPC-SP 5/NACE No. 1 White Metal Blast Cleaning.
 - 6. SSPC-SP 6/NACE No. 3 Commercial Blast Cleaning.
 - 7. SSPC-SP 10/NACE No. 2 Near White Blast Cleaning.
 - 8. SSPC-SP 11 Power Tool Cleaning to Bare Metal.
 - 9. SSPC-SP13/NACE No. 6 Surface Preparation of Concrete.
 - 10. SSPC-PA 1 Shop, Field, & Maintenance Painting.
 - 11. SSPC-PA 2 Measurement of Dry Paint Thickness with Magnetic Gages.
 - 12. SSPC-PA Guide to Safety in Paint Application Guide 3.
 - 13. SSPC-VIS 1 Pictorial Surface Preparation Standards for Painting Steel Surfaces.

14. SSPC-A31 Mineral and Slag Abrasives.
 15. SSPC-WJ 4/NACE WJ 4 Light Water jetting
 16. SSPC Surface Preparation Commentary for Metal Substrates
- D. National Association of Corrosion Engineers (NACE) standards
1. SP0892-2007 - Coatings and Linings over Concrete for Chemical Immersion and Containment Service.

1.4 PERFORMANCE REQUIREMENTS

- A. Coating for final coats shall be fume resistant, compounded with pigment suitable for exposure to sewage gases, especially to hydrogen sulfide and to carbon dioxide. Coating material shall be able to handle harsh abrasives such as sand and grit.
- B. Pigments shall be materials that do not darken, discolor, or fade due to action of sewage gases.

1.5 SUBMITTALS

- A. Submit in accordance with Section 01 33 00 – Submittals.
- B. Product Data: Furnish the following:
 1. Data Sheets:
 - a. For each paint system used herein, furnish
 - 1) Paint System Data Sheet. A sample PSDS form is appended to the end of this section.
 - 2) Technical Data Sheets – Including:
 - a) Solids Content.
 - b) Ingredient analysis.
 - c) VOC content.
 - d) Chemical resistance.
 - e) Temperature resistance.
 - f) Typical exposures and limitations.

- b. Manufacturer's Instructions including:
- 1) Special requirements for transportation and storage.
 - 2) Mixing instructions.
 - 3) Shelf life.
 - 4) Pot life of materials.
 - 5) Precautions for application free of defects.
 - 6) Surface preparation.
 - 7) Method of application.
 - 8) Recommended number of coats.
 - 9) Recommended thickness of each coat.
 - 10) Recommended total thickness.
 - 11) Drying time for each coat, including prime coat.
 - 12) Required prime coat.
 - 13) Compatible and non-compatible prime coats.
 - 14) Recommended thinners, when recommended.
 - 15) Limits of ambient conditions during and after application.
 - 16) Time allowed between coats.
 - 17) Required protection from sun, wind, and other conditions.
 - 18) Touch-up requirements and limitations.
- c. Paint colors available (where applicable) for each product used in the paint system in accordance with Section 22 05 53.05.
- d. Maintenance & Repair Instructions.
- e. Regulatory Requirements: VOC compound limitations, coatings containing lead compounds, abrasive, abrasive blast cleaning techniques, and disposal.
- f. Indiscriminate submittal of manufacturer's literature only is not acceptable.

2. Alternate Paint Systems: Furnish information as required for specified products if proposing to furnish alternate products.
 3. Furnish manufacturer's written instructions for applying each type of paint or protective coating prior to application.
 4. Also provide copies of paint system submittals to the coating applicator.
- C. Samples: Furnish the following:
1. Reference Panel:
 - a. Prior to start of surface preparation, furnish a 4-inch by 4-inch steel panel for each grade of sandblast specified herein, prepared to specified requirements.
 - b. Provide panel representative of the steel used and prevent from deterioration of surface quality.
 - c. Upon approval by District, preserve panel as a reference source for inspection.
 2. Unless otherwise specified, before painting work is started, prepare minimum 8- by 10-inch samples with type of paint and application specified on similar substrate to which paint is to be applied.
 3. Furnish additional samples as required until colors, finishes, and textures are approved.
 4. Retain approved samples to be used as the quality standard for final finishes.
- D. Quality Control Submittals: Furnish the following:
1. Applicator's Experience: List of references substantiating the requirement as specified.
 2. Factory Applied Coatings: Manufacturer's certification stating factory applied coating system meets or exceeds requirements specified herein.
 3. If the manufacturer of finish coating differs from that of shop primer, provide manufacturer's written confirmation that materials are compatible.
 4. Adhesion test documentation as applicable.

- E. Substitute or “Or Equal” Submittals: Unless otherwise specified, materials shall be from catalogs of the companies listed herein. Materials from other manufacturers are acceptable provided that they are established as being compatible with and of equal quality to the coatings of the companies listed. The Contractor shall provide satisfactory proof from the firm manufacturing the proposed substitution.

1.6 QUALITY ASSURANCE

- A. The paint manufacturer shall provide a representative to visit the jobsite at intervals during surface preparation and painting as may be required for product application quality assurance, and to determine compliance with manufacturer's instructions and these Specifications, and as may be necessary to resolve field problems attributable to, or associated with, the manufacturer's products furnished under this Contract.

Applicator's Experience: Minimum 5 years' practical experience in application of specified products.

- B. Mockup:
 - 1. Before proceeding with work under this section, finish one complete space or item of each color scheme required showing selected colors, finish texture, materials, and workmanship.
 - 2. After approval, sample spaces or items shall serve as a standard for similar work throughout the project.
- C. Standardization: Materials and supplies provided shall be the standard products of manufacturers. Materials in each coating system shall be the products of a single manufacturer.

1.7 PAINT DELIVERY, STORAGE, AND HANDLING

- A. Deliver paint to project site in unopened containers that plainly show, at time of use, the designated name, date of manufacture, color, and name of manufacturer.
- B. Store paints in a suitable protected area that is heated or cooled as required to maintain temperatures within the range recommended by paint manufacturer.
- C. Shipping:
 - 1. Where pre-coated items are to be shipped to the jobsite, protect coating from damage. Batten coated items to prevent abrasion.
 - 2. Use nonmetallic or padded slings and straps in handling.
 - 3. Items will be rejected for excessive damage.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Primer, intermediate, and finish coats shall be of same manufacturer.
- B. Products shall meet federal, state, and local requirements limiting the emission of volatile organic compounds. Specific information may be secured through the office of the Bay Area Air Quality Management District (BAAQMD).
- C. Coatings in contact with potable water shall be certified by the National Sanitation Foundation in accordance with ANSI/NSF Standard 61.
- D. Protective interior coatings for valves and hydrants shall conform to the requirements of American Water Works Association coating standard C550.
- E. Coating systems also apply to recoating of existing surfaces if specified to be recoated on the Drawings and/or in this specification.
- F. Formulate with colorants free of lead, lead compounds, or other materials which might be affected by presence of hydrogen sulfide or other gases at the project site.
- G. Liquid-epoxy coating for the interior and exterior of steel water pipelines shall conform to the requirements of American Water Works Association coating standard C210.

2.2 PAINTING AND COATING SYSTEMS

- A. Generic coating systems, film thickness, and surface preparation requirements are shown as follows. Specific surface preparation and coating system for each item or area shown on drawings or specified in other specifications sections shall be submitted for review using specified Paint System Data Sheet.

2.3 PAINTING AND COATINGS MATERIALS

- A. District-accepted manufacturer's materials (or Equal) shall be used for the Painting and Coating Systems per Table 2.
- B. Thinners and solvents as specified by the coating system manufacturer.

Table 1 - System Coatings

| System No. | Paint Materials (Each line indicates one coat) | Required # of Coats, Min. Cover (MDFT) | Surface Prep. |
|------------|--|--|--|
| 4 | Epoxy, High Solids | 1 coat, 10 mil | For metal, SSPC-SP10/NACE No. 2 |
| | Epoxy, High Solids | 1 coat, 10 mil | |
| 8 | Epoxy, Atmospheric | 1 coat, 4 mil | For metal, SSPC-SP6. For concrete, SSPC-SP13 and ICRI 310.2, CSP 2 – 5. For plastic, refer to Article 3.7D |
| | Epoxy, Atmospheric | 1 coat, 4 mil | |
| | Polyurethane, Aliphatic | 1 coat, 4 mil | |

Table 2 - Paintings and Coatings Materials

| | Sherwin Williams | PPG Protective & Marine Coatings | Carboline Company | Tnemec Company, Inc | Devoe Coatings Company |
|--------------------------------|------------------------|----------------------------------|---------------------------------------|-------------------------------|------------------------|
| Epoxy, Atmospheric | Macropoxy 646 | Amerlock 2 | Carboguard 890 | Series L69 Hi-Build Epoxoline | Bar-Rust 235V |
| Epoxy, High Solids | SherGlass FF | Amercoat 240 | Carboguard 891HS | Series 104 H.S. Epoxy | Bar-Rust 233H |
| Polyurethane, Aliphatic | Hi Solids Polyurethane | Amershield VOC | Carbothane 134 VOC Aliphatic Urethane | Series 1095 Endura-Shield | Devthane 378H |

2.4 COLORS

A. Equipment Colors:

1. Equipment shall include the machinery or vessel itself plus the structural supports and fasteners and attached electrical conduits.
2. Paint non-submerged portions of equipment the same color as the process piping it serves, except as itemized below:
 - a. Dangerous Parts of Equipment and Machinery: OSHA Orange.
 - b. Fire Protection Equipment and Apparatus: OSHA Red.
 - c. Pressure Hazards: OSHA Purple.
 - d. Physical Hazards in Normal Operating Area: OSHA Yellow.
3. Fiberglass reinforced plastic (FRP) equipment with an integral colored gel coat does not require painting, provided the color is as specified and unless specified otherwise.
4. See Section 22 05 53.05 for table of piping system color codes.

PART 3 - EXECUTION

3.1 GENERAL

- A. Surface Preparation Inspection:
 - 1. Inspect and provide substrate surfaces prepared in accordance with these Specifications and the printed directions and recommendations of paint manufacturer whose product is to be applied.
 - 2. Provide District minimum 3 days' advance notice prior to start of surface preparation work or coating application work.
 - 3. Perform such work only in presence of District unless District grants prior approval to perform such work in District's absence.
- B. Mix and apply all coatings in accordance with the manufacturer's instructions, the applicable requirements of SSPC-PA 1, and as specified herein.
- C. For coatings subject to immersion, obtain full cure for completed system. Consult coatings manufacturer's written instructions for these requirements. Do not immerse coating for any purpose until completion of curing cycle.
- D. The intention of these Specifications is for new, interior, and exterior metal and submerged metal surfaces to be painted, whether specifically mentioned or not, except as modified herein. All other concealed structural steel surfaces shall be coated as specified.
- E. Do not apply paint in temperatures exceeding manufacturer's recommended maximum or minimum allowable, or in dust, smoke-laden atmosphere, damp or humid weather.
- F. Do not perform abrasive blast cleaning whenever relative humidity exceeds 85 percent, or whenever surface temperature is less than 5 degrees F above dewpoint of ambient air.
- G. Provide fans, heating devices, or other means recommended by coating manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats, and within curing time following application of last coat.
- H. Provide adequate continuous ventilation and sufficient heating facilities to maintain a minimum of 45 degrees Fahrenheit for 24 hours before, during, and 48 hours after application of finishes.
- I. After award of contract, Contractor, and its coating subcontractor, shall attend a pre-job meeting at the job site prior to starting work or purchasing coating materials.

3.2 SURFACES NOT REQUIRING PAINTING

- A. Unless otherwise stated herein or shown, the following areas or items will not require painting:
1. Nonferrous and corrosion-resistant ferrous alloys such as bronze, monel, aluminum, chromium plate, atmospherically exposed weathering steel, and stainless steel, except where:
 - a. Required for electrical insulation between dissimilar metals.
 - b. Aluminum and stainless steel are embedded in concrete or masonry, or aluminum is in contact with concrete or masonry.
 2. Glass and porcelain.
 3. Prefinished electrical and architectural items such as motor control centers, switchboards, switchgear, panel boards, transformers, disconnect switches, building louvers, wall panels, etc.; color coding of equipment is required.
 4. Non-submerged electrical conduits attached to unpainted concrete surfaces
 5. Items specified to be galvanized after fabrication unless specified elsewhere or subject to immersion or embedment in concrete.
 6. Flexible Tubing (Tygon).
 7. Stainless steel tubing.
 8. Copper tubing less than or equal to ½-inch diameter.
 9. Pipe and bolt threads.
 10. Existing FRP vessels.
- B. Manufactured items and materials that are "factory" galvanized or existing galvanized surfaces shall be coated as specified hereinafter for the exposure condition of the item and for architectural purposes, unless specified herein.
- C. Protection of materials not to be painted:
1. Remove, mask, or otherwise protect hardware, lighting fixtures, switch plates, aluminum surfaces, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not intended to be painted.
 2. Provide drop cloths to prevent paint materials from falling on or marring adjacent surfaces.

3. Protect working parts of mechanical and electrical equipment from damage during surface preparation and painting process.
4. Mask openings in motors to prevent paint and other materials from entering the motors.

3.3 COATING SYSTEM APPLICATION SCHEDULE

A. General:

1. Coat all exposed surfaces as shown in Table 3. Coordinate field and shop painting and surface preparation and application. Ensure shop applied primers and surface preparation conform to these specification requirements and are compatible with field applied finish coats.
2. Prepare shop applied coatings, damaged shop applied coating and exposed substrates prior to applying field finish coats.
3. The equipment and materials listed in Article 3.3 under each category are included to provide clarity for each category; however, they are only examples and all surfaces which meet the category shall be coated with the specified System.
4. Refer to drawings and specifications for existing surfaces requiring recoating.

3.4 RECOATING OF EXISTING COATED SURFACES

- A. Existing coated surfaces requiring recoating, as indicated in Drawings or Specifications, shall be recoated per the requirements of this Specification.
- B. Surface preparation of existing coated surfaces requiring recoating shall conform to the requirements of Article 3.7 Section E of this Specification
- C. All exposed existing coated surfaces requiring recoating shall be coated with the system indicated in Table 3.

Table 3 - System Coatings Execution

| Surface /Location | Exposure | Interior /Exterior | Coating System | Example Locations |
|-------------------|--|-------------------------|---|---|
| Metal | | | System 2 (NOT USED) | |
| | | | System 13 (NOT USED) | |
| | | | System 8 (NOT USED) | |
| | | | System 1 (NOT USED) | |
| | | | | |
| | | | | |
| | Subject to Submersion, medium corrosion, or medium flows | n/a | System 4 (or System 4F for Fast Cure) | Pipe, valves and gates, valve and gate operators and stands, pipe hangers, supports and saddles, conduit, cable tray hangers, and supports NOTE: The entire SD-409 Project area is considered medium corrosion exposure. |
| | n/a | System 6 (NOT USED) | | |
| | n/a | System 7 (NOT USED) | | |
| | | | System 8 (NOT USED) | |
| | | | System 1 (NOT USED) | |
| | | System 12 (NOT USED) | | |
| | | n/a | System 3 (NOT USED) | |
| | | n/a | System 5 (NOT USED) | |
| FRP, PVC, CPVC | n/a | Exterior | System 8 | All exterior fiberglass, PVC, and CPVC surfaces. Exclude Intermediate Coat. |
| | | | System 1 (NOT USED) | |
| | n/a | | System 11 (NOT USED) | |

3.5 APPLICATION SAFETY

- A. Perform painting in accordance with recommendations of the following:
 - 1. Paint manufacturer's instructions.
 - 2. NACE, contained in the publication, Manual for Painter Safety.
 - 3. Federal, state, and local agencies having jurisdiction.

3.6 PAINT MIXING

- A. Multiple-Component Coatings:
 - 1. Prepare using all the contents of the container for each component as specified and packaged by paint manufacturer. No partial batches will be permitted.
 - 2. Do not use multiple-component coatings that have been mixed beyond their pot life.
 - 3. Provide small quantity kits for touchup painting and for painting other small areas.
 - 4. Do not intermix additional components for reasons of color or otherwise, even within the same generic type of coating.
- B. Keep paint materials sealed when not in use.
- C. Where more than one coat of a material is applied within a given system, alternate color to provide a visual reference that the required number of coats have been applied.

3.7 PREPARATION OF SURFACES

- A. GENERAL
 - 1. Prepare surfaces per manufacturer's recommendation.
- B. Metal Surface Preparation:
 - 1. Do not perform a surface preparation blast prior to submission of samples. Workmanship for metal surface preparation as specified shall meet current SSPC Specifications as follows:
 - a. Solvent Cleaning: SP 1.
 - b. Hand Tool Cleaning: SP 2.
 - c. Power Tool Cleaning: SP 3.

- d. White Metal Blast Cleaning: SP 5/NACE No. 1.
 - e. Commercial Blast Cleaning: SP 6/NACE No. 3.
 - f. Brush-Off Blast Cleaning: SP 7/ NACE No. 4.
 - g. Pickling: SP 8.
 - h. Near-White Blast Cleaning: SP 10/NACE No. 2.
 - i. Power Tool Cleaning to Bare Metal: SP 11
 - j. Light Water jetting: SP WJ-4
2. Wherever the words "solvent cleaning", "hand tool cleaning", "wire brushing", or "blast cleaning", or similar words of equal intent are used in these Specifications or in paint manufacturer's specifications, they shall be understood to refer to the applicable SSPC Specifications listed above.
 3. Where OSHA or EPA regulations preclude standard abrasive blast cleaning, wet or vacu-blast methods may be required. Coating manufacturers' recommendations for wet blast additives and first coat application shall apply.
 4. Hand tool clean areas that cannot be cleaned by power tool cleaning.
 5. Repair defects deeper than 12.5% of nominal thickness of steel by repair welding and grinding smooth.
- C. CPVC, PVC, and FRP Surface Preparation:
1. Solvent wipe to remove any dirt or residue off pipe to be coated.
 2. Sand the area to be coated with 100-200 grit paper and then remove sanding residue with solvent wipe.
 3. Large areas may be power sanded or brushoff blasted, provided sufficient controls are employed so surface is roughened without removing excess material.
- D. Preparation of Existing Coated or Primed Surfaces:
1. All surfaces to be Repainted or Final Coated: Pressure wash clean all surfaces per SP WJ-4.
 2. Spot clean per SP 1 to remove visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants.
 3. Clean loose, abraded, or damaged coatings to substrate by Hand or Power Tool, SP 2 or SP 3.

4. All previously coated and existing painted surfaces shall be thoroughly and completely abraded. Existing coatings shall be sufficiently deglossed and profiled for application of prime coats.
 5. All corroded surfaces shall be mechanically cleaned per SP 11 to remove all corrosion or deteriorated material.
 6. Feather surrounding intact coating.
 7. Apply one spot coat of the specified primer to bare areas, overlapping prepared existing coating a minimum of one inch.
 8. Apply one full intermediate and finish coat of the specified primer or finish coat(s) overall.
 9. If an aged, plural-component material is to be top-coated, contact coating manufacturer concerned for additional surface preparation requirements.
 10. Ductile iron pipe for above-ground installation shall be ordered with a primer coating. Ductile iron pipe for buried applications, which has a black varnish coating, shall be removed by abrasive blasting prior to recoating with a suitable above-ground coating in accordance with Table 3.
 11. Application of Cosmetic Coat:
 - a. The exact nature of existing coatings is not known in all cases, however, the specifications assume they have oxidized sufficiently to prevent lifting or peeling when over-coated with paints specified.
 - b. Check compatibility by application to a small area prior to starting painting.
 - c. If lifting or other problems occur, request disposition from Engineer.
- E. Pre-Blast Cleaning Requirements:
1. Remove oil, grease, welding fluxes, and other surface contaminants prior to blast cleaning.
 2. Cleaning Methods: Steam, open flame, hot water, or cold water with appropriate detergent additives followed with clean water rinsing.
 3. Clean small, isolated areas as above or solvent clean with suitable solvents and clean cloths.

4. Round or chamfer sharp edges and grind smooth burrs, jagged edges, and surface defects.
 5. Welds and Adjacent Areas:
 - a. Prepare such that there is: No undercutting or reverse ridges on weld bead. No weld spatter on or adjacent to weld or any other area to be painted. No sharp peaks or ridges along weld bead.
 - b. Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.
- F. Blast Cleaning Requirements:
1. Meet applicable federal, state, and local air pollution and environmental control regulations for aggregate types, blast cleaning procedures and disposition of spent aggregate and debris.
 2. Select type and size of abrasive to produce a surface profile that meets coating manufacturer's recommendations for particular primer to be used.
 3. Use only dry blast cleaning methods unless an approved abrasive recycling system is used that removes debris and spent abrasive.
 4. Type of Equipment and Speed of Travel: Design to obtain specified degree of cleanliness.
- G. Post-Blast Cleaning and Other Cleaning Requirements:
1. Clean surfaces of dust and residual particles from cleaning operations by dry (no oil or water vapor) air blast cleaning or other method prior to painting. Vacuum clean enclosed areas and other areas where dust settling is a problem and wipe with a tack cloth.
 2. Paint surfaces the same day they are sandblasted. Reblast surfaces that have started to rust before they are painted.
- H. Brushoff Blast Cleaning:
1. Equipment, procedure, and degree of cleaning shall meet SSPC-SP 7, Brushoff Blast Cleaning.
 2. Abrasive: Either wet or dry blasting sand, grit, or nutshell.
 3. Select various surface preparation parameters such as size and hardness of abrasive, nozzle size, air pressure, and nozzle distance from surface such that surface is cleaned without pitting, chipping, or other damage.
 4. Verify parameter selection by blast cleaning a trial area that will not be exposed to view.

5. District shall approve trial blast cleaned area and shall use area as a representative sample of surface preparation.
6. Repair or replace surfaces damaged by blast cleaning.

I. Acid Etching:

1. After pre-cleaning, spread the following solution by brush or plastic sprinkling can: 1-part commercial muriatic acid reduced by 2 parts water by volume. Adding acid to water in these proportions gives an approximate 10 percent solution of HCl.
2. Application:
 - a. Application Rate: Approximately 2 gallons per 100 square feet.
 - b. Work acid solution into surface by hard-bristled brushes or brooms until complete wetting and coverage is obtained.
 - c. Acid will react vigorously for a few minutes, during which time brushing is continued.
 - d. After bubbling subsides (10 minutes), hose down the remaining slurry with high pressure clean water.
 - e. Rinse immediately to avoid formation of salts on the surface which are difficult to remove.
 - f. Thoroughly rinse to remove any residual acid surface condition which can impair adhesion.
3. Ensure surface is completely dry before application of coating.
4. After etching, surface shall be "grainy" to the touch. If not, repeat treatment.

J. SHOP BLAST CLEANING

1. Notify District at least 7 days prior to start of shop blast cleaning of any equipment or piping materials to allow for inspection of the work during surface preparation and shop application of paints. Work shall be subject to District's approval before shipment to jobsite.
2. Items such as structural steel, metal doors and frames, metal louvers, and similar items as reviewed by District may be shop prepared and primed. Centrifugal wheel blast cleaning is an acceptable alternate to shop blast cleaning. Blast clean and prime work in accordance with these Specifications.
3. Finish Painting at Jobsite: As specified herein.

4. For factory primed surfaces, pre-clean per SSPC-SP 1, lightly sand with 100 grit paper, and solvent clean per SSPC-SP 1 prior to applying High Build Epoxy

K. FIELD SANDBLASTING

1. Perform sandblasting for items and equipment where specified and as required to restore damaged surfaces previously shop or field blasted and primed. Materials, equipment, procedures shall meet requirements of Steel Structures Painting Council.

3.8 APPLICATION OF PAINT

A. General:

1. Inspection: Schedule with District in advance for cleaned surfaces and all coats prior to succeeding coat.
2. Apply coatings in accordance with paint manufacturer's recommendations, including environmental controls, product handling, mixing, application equipment, and coating methods. Allow sufficient time between coats to assure thorough drying of previously applied paint.
3. For units or structures requiring assembly or installation: Paint the units to be bolted together and/or to the structures prior to assembly or installation.
4. Coating shall interface with adjoining construction materials/components to effectively seal and protect the substrate.
5. Stripe coat all angles, edges and welds in tanks and highly corrosive atmospheric exposure before applying specified painting system.
6. Contractor shall employ mist coat/full coat spray techniques or other suitable measures to minimize blistering of finish coatings applied over inorganic zinc-primed surfaces.
7. Mist coat/full coat application shall be as follows: Mist coat shall consist of application of approximately 1 wet mil of coating and allowing it to stand for 30 seconds to 1 minute or until bubbling ceases. Then apply a wet coat in even, parallel passes, overlapping each pass 50 percent. If required, follow with a cross-spray pass at right angles to the first pass so that the full coat of material is applied to the surface.
8. Verify spray equipment is in working order and can accurately ratio and apply the coating product.
9. Verify only applicators meeting the proper quality assurance requirements are performing all aspects of the coating work.

B. Shop Primed or Factory Finished Surfaces:

1. Inspection: Schedule with District in advance for shop primed or factory finished items delivered to jobsite for compliance with Specifications.
2. Hand or power sand areas of chipped, peeled, or abraded coating, feathering the edges. Follow with a spot primer using specified primer.
3. For two-package or converted coatings, consult coatings manufacturer for specific procedures as relates to manufacturer's products.
4. Prior to application of finish coats, clean shop primed surfaces free of dirt, oil, and grease and apply mist coat of specified primer, 1-mil dry film thickness.
5. After welding, prepare and prime holdback areas as required for specified paint system. Apply primer in accordance with manufacturer's instructions.

C. Manufacturer Applied Paint Systems:

1. Repair abraded areas on factory finished items in accordance with the equipment manufacturer's directions.
2. Carefully blend repaired areas into original finish.

D. Porous Surfaces, Such As Concrete Masonry:

1. Prime Coat:
 - a. May be thinned to provide maximum penetration and adhesion.
 - b. Type and Amount of Thinning: Determined by paint manufacturer and dependent on surface density and type of coating.
2. Surfaces Specified to Receive Water Base Coating: Dampen, but keep free of running water, just prior to application of coating.

E. Film Thickness:

1. Coverage is listed as either total minimum dry film thickness in mils (MDFT) or the spreading rate in square feet per gallon (SFPG). Per coat determinations are listed as MDFTPC or SFPGPC.
2. Number of Coats: Minimum required irrespective of coating thickness. Additional coats may be required to obtain minimum required paint thickness, depending on method of application, differences in manufacturers' products, and atmospheric conditions.

3. Maximum film build per coat shall not exceed coating manufacturer's recommendations.
 4. Check each coat for correct millage. Do not make measurement before a minimum of 8 hours after application of coating.
 5. Visually inspect concrete, nonferrous metal, plastic, and wood surfaces to ensure proper and complete coverage has been attained.
 6. Give particular attention to edges, angles, flanges, and other similar areas, where insufficient film thicknesses are likely to be present, and ensure proper millage in these areas.
 7. All coats are subject to inspection by the District or a District designated representative.
 8. See Quality Control section below for Thickness Testing.
- F. Damaged Coatings, Pinholes, and Holidays:
1. Feather edges and repair in accordance with recommendations of paint manufacturer.
 2. Repair fusion bonded coatings as recommended by original applicator. Applicator shall provide liquid repair kits for this purpose as recommended by coating manufacturer.
 3. Apply finish coats, including touchup and damage-repair coats in a manner which will present a uniform texture and color-matched appearance.
- G. Unsatisfactory Application:
1. If item has an improper finish color, or insufficient film thickness, clean and topcoat surface with specified paint material to obtain specified color and coverage. Obtain specific surface preparation information from coating manufacturer.
 2. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather the edges. Follow with primer and finish coat in accordance with the Specifications. Depending on extent of repair and appearance, a finish sanding and topcoat may be required.
 3. Evidence of runs, bridges, shiners, laps, or other imperfections shall be cause for rejection.
 4. Repair defects in coating system per written recommendations of coating manufacturer.

3.9 QUALITY CONTROL

- A. Measure relative humidity and metal surface temperature and determine dew point each day prior to painting. Repeat measurements as often as the District deems necessary but not less often than every four hours.
 - 1. The District will also measure relative humidity and metal surface temperature and determine dew point at least once each day that painting is performed.
- B. The District will evaluate surface preparation using SSPC-VIS 1 and replica tapes. Evaluation of cleanliness will be made immediately prior to coating application.
- C. Verify cleanliness of all spray application equipment prior to, or no later than, time of mixing coating material.
- D. District will evaluate cleanliness of coated surface immediately prior to application of a subsequent coat.
- E. Leave all staging up until District has inspected surface or coating. Replace staging removed prior to approval by District.
- F. Film Thickness Testing and Electrical Inspection of Coated Surfaces:
 - 1. Perform with properly calibrated instruments.
 - 2. Recoat and repair as necessary for compliance with the Specifications.
 - 3. Measure coating thickness after each coat using non-destructive magnetic dry film gauges.
 - a. Measure in accordance with SSPC-PA 2.
 - b. District will also measure coating thickness, at random locations, after each coat.
 - 4. Repair areas not meeting thickness requirements per Application Section above. Retest after coating repairs.
- G. Holiday Testing
 - 1. Contractor shall test all coated surfaces for pinholes and holidays after application of the final coat.
 - 2. Perform test in presence of the District.
 - 3. Perform test after coating has cured per manufacturer's recommendation.

4. As directed by the District, use either a low voltage wet sponge holiday detector or a high voltage holiday detector.
 - a. Low voltage wet sponge holiday detector shall be equal to K-D Bird or Tinker & Rasor M-1. Add a non-sudsing wetting agent, such as Eastman Kodak Photo-Flo to the water used to saturate the sponge.
 - b. High voltage holiday detector shall be equal to Tinker & Rasor AP-W or D. E. Stearns Model 14/20, for coatings greater than 20-mil thickness. Use in accordance with coating manufacturer's recommendations except use voltage of 150 volts per mil of coating.
 - c. Repair holidays per Application Section above. Retest after coating repairs.

- H. Pull (Adhesion) Testing for high-build epoxy coatings on steel.
 1. Pull tests are required for high-build epoxy coatings on steel.
 2. For coating on existing structures, pull tests are also required on substrate or substrate repair material prior to coating pull test.
 3. Tests shall be conducted after the coating system has cured in accordance with manufacturer's specifications.
 4. Tests shall be conducted per ASTM D4541 or ASTM D7234 using a self-aligning Type V adhesion tester.
 5. Testing shall be performed by NACE certified personnel using equipment calibrated per applicable manufacturer and/or ASTM standards.
 6. Number of pull tests required shall be calculated as follows:
 - a. One pull test per 250 square feet, minimum, of surface area coated.
 - b. One pull test for each separate component with surface area less than 250 square feet.
 7. Pull tests in each area shall meet or exceed 400 psi on coated metallic substrates.
 8. If any test fails, a minimum of 3 additional locations in the section of failure shall be tested, as directed by the Engineer. If any of the retests fail, all loosely adhered or unadhered coating in the failed area, as determined by the Engineer, shall be removed, and replaced at the Contractor's expense.

9. Adhesion tests shall be documented and submitted to Engineer in consistent format detailing location, test values, description of failure point/mode, scoring method employed, adhesive used, cure time of coating, adhesive, and other data as deemed necessary by Engineer.

3.10 CLEANUP

- A. Remove all spattering, spits, and blemishes caused by work under this section.
- B. Upon completion, remove from the premises all surplus paint materials, abrasive blast materials, equipment, rubbish, and debris resulting from work under this sections.
- C. Remove spent abrasive blast material in accordance with Section 01 35 24 – Project Safety Requirements, regarding potential hazardous conditions and hazardous substances.
- D. Place cloths and waste that might constitute a fire hazard in closed metal containers or destroy at the end of each day.
- E. Upon completion of the work, remove staging, scaffolding, and containers from the site or destroy in a legal manner.
- F. Completely remove paint spots, oil, or stains upon adjacent surfaces and floors and leave entire job clean.

[See Paint System Data Sheet (PSDP) form following this Section.]

PAINT SYSTEM DATA SHEET

Attached products' Technical Data Sheet (if applicable) to this sheet for each paint system submittal.

| | | |
|-----------------------------------|--------------------------------------|---------------------|
| Paint System Number (from Spec.): | | |
| Paint System Title (from Spec.): | | |
| Coatings Supplier: | | |
| Representative: | | |
| Surface Preparation: | | |
| | Product Name/Number (Proprietary) | |
| Paint Material (Generic) | (Proprietary) | Min. Coats Coverage |
| | | |
| | | |
| | | |

END OF SECTION

SECTION 22 05 53.05

PIPE IDENTIFICATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Furnish and install piping identification markers for exposed piping as specified herein.
- B. Related work specified elsewhere:
 - 1. Section 09 90 00 – Painting and Coatings
 - 2. Section 40 05 01 – Piping Systems.

1.2 REFERENCES

- A. American National Standards Institute (ANSI) Z535.1 – Safety Color Code

1.3 SUBMITTALS

- A. Submit the following as specified herein and in accordance with Section 01 33 00, Submittal Procedures:
- B. Descriptive literature for markers: The literature and drawings shall contain the manufacturer's name, description, manufacturers' product data, and the full item number or designation.
- C. Piping marker table listing each piping service with proposed marker lettering and colors.

PART 2 - PRODUCTS

2.1 PAINTING

- A. Paint as specified in Section 09 90 00, Painting and Coatings and per schedule.
- B. Pipe System Color shall be as specified in the Schedule.
- C. Special Items:
 - 1. In addition, special painting of following items will be required:

| Item | Color |
|------------------------|--------------------------|
| Hoist hooks and blocks | Yellow and black stripes |
| Steel guard posts | ANSI Safety Yellow |

2.2 ADHESIVE MARKERS

- A. Self-adhesive vinyl, suitable for outdoor application from – 40 degrees to 180 degrees Fahrenheit.
- B. Minimum thickness shall be 0.004-inch.
- C. Each marker shall include:
 - 1. Multiple axial-mounted text blocks to allow visibility from all likely viewing directions.
 - 2. Pipe banding tape with repeating flow arrows surrounding the entire pipe circumference on both ends of the pipe marker. Arrow colors shall be the same as the lettering color.
- D. Marker Colors:
 - 1. Refer to the Standard Drawing (STD-G-005) for the marker lettering and background colors for label use.
- E. Lettering:

| Pipe Outer Diameter | Lettering Size |
|----------------------------|-------------------------|
| Less than 0.75 inches | Permanently legible tag |
| 0.75 inches to 1.25 inches | 1/2 inch |
| 1.5 inches to 2 inches | 3/4 inch |
| 2.5 inches to 6 inches | 1-1/4 inches |
| 8 inches to 10 inches | 2-1/2 inches |
| over 10 inches | 3-1/2 inches |

- F. As manufactured by:
 - 1. Seton, Opti Code Pipe Markers
 - 2. Lab Safety Supply
 - 3. or equal.

PART 3 - EXECUTION

3.1 PAINTING

- A. Color Code:
 - 1. Paint piping scheduled to be color coded completely with specified colors.

3.2 ADHESIVE MARKER

- A. Prepare surface in accordance with product manufacturer's instructions. Ensure surface is clean, dry, and free of dust or debris.
- B. Identify piping with legend markers, directional arrow markers, and number markers; use self-adhesive arrow roll tape to secure ends of piping markers and indicate flow direction.
- C. Provide piping marker letters and colors as scheduled.
- D. Install adhesive markers at the following locations:
 - 1. adjacent to equipment served and adjacent to valves
 - 2. both sides of walls and floors where pipe passes through
 - 3. adjacent to changes in direction (e.g., upstream, and downstream of elbows, bends, tees, etc.)
 - 4. at intervals of not more than 20 feet in straight runs of pipe
- E. Place markers on piping so they are visible from operator's position in walkway or working platform near piping. Locate markers along horizontal centerline of pipe, unless better visibility is achieved elsewhere. Install two labels on opposite, or near opposite, sides of the pipe if pipe is visible from two directions (e.g., piping crossing between two work areas or walkways).

3.3 PIPING SYSTEM COLOR SCHEDULE

| ID | PIPING SYSTEM | PIPE (SYSTEM) COLOR | COLOR CODE | | | | |
|-----|---|--|------------|---------|-----------|-----------|------------|
| | | | Tnemec | Devoe | Carboline | PPG | S-W |
| AHP | Air, High Pressure (Plant Utility) | ANSI Safety Green | 09SF | DC9700 | N306 | PC855 | 4085 |
| IA | Air, Instrument | | | | | | |
| ALP | Air, Low Pressure | | | | | | |
| CA | Caustic Soda | ANSI Safety Orange | 04SF | DC9200 | 1420 | PC885 | 4083 |
| FCL | Ferric Chloride | | | | | | |
| SA | Sulfuric Acid | | | | | | |
| SB | Sodium Bisulfite | ANSI Safe Yellow | 02SF | DC9400 | 8672 | PC875 | 4084 |
| SHC | Sodium Hypochlorite | | | | | | |
| NG | Natural Gas | International Orange | 05SF | DC6900 | Match | PC891 | 4082 |
| 5W | Fire Service | ANSI Safety Red | 06SF | DC9000 | 7573 | PC895 | 4081 |
| RW | Reclaimed Water | ANSI Safety Purple | 14SF | DC9600 | 7528 | PC893 | 4080 |
| 1W | Potable Water (1W) | ANSI Safety Blue | 11SF | DC9800 | 9112 | PC865 | 4086 |
| RS | Pump Sta. Raw Sewage | Pump Station Red | 07SF | Match | 2554 | 7522 | Match |
| O2 | Oxygen (SST) | None | -- | -- | -- | -- | -- |
| DG | Digester Gas (SST) | None | -- | -- | -- | -- | -- |
| -- | MWWTP Process – All Other Exterior (epoxy) | Popcorn | 1029 -PA21 | Match | 0842 | 2012-1531 | CCC0471-15 |
| -- | MWWTP Process – All Other Exterior (polyurethane) | Popcorn | Match | Match | Match | 2012-1532 | CCC0473-15 |
| -- | MWWTP Interior (Epoxy) | Popcorn | Match | Match | Match | Match | CCC0472-15 |
| -- | All PVC piping | None | -- | -- | -- | -- | -- |
| -- | All PE or HDPE piping | Use solid color pipe or co-extrusion stripes based on the piping system color. | Various | Various | Various | Various | Various |

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR ODOR CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Scope:

1. This Section covers the cleaning, testing, adjusting, and balancing of the air system(s) associated with the odor control system(s).

B. Governing Standards:

1. Except as modified or supplemented herein, all work covered by this Section shall be performed in accordance with all applicable municipal codes and ordinances, laws, and regulations. In case of a conflict between any state law or local ordinance and this Section the latter shall take precedence.
2. All work shall comply with the latest edition of AABC, NEBB, or SMACNA standard manuals for testing, adjusting, and balancing of air systems.

C. Work Included: Provisions for testing, adjusting, and balancing of odor control systems under actual operating conditions and design flow rates, including:

1. Taking pre-tests of existing systems as identified on the Drawings.
2. Balancing airflow within distribution systems, including sub-mains, branches, and terminals, to specified quantities according to specified tolerances.
3. Adjusting total odor control systems to provide specified quantities.
4. Measuring electrical performance of odor control equipment.
5. Setting quantitative performance of odor control equipment.
6. Verifying that automatic control devices are functioning properly.
7. Measuring sound and vibration.
8. Reporting results of the activities and procedures specified in this Section.

1.2 RELATED SECTIONS

- A. As required by Division 01 - General Requirements.

1.3 SUBMITTALS

- A. The following information shall be provided in accordance with Section 01 33 00.
 - 1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (√) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and therefore requested by the Manufacturer, underline each deviation and denote by a number in the margin to the right of the identified paragraph. Provide a detailed, written justification for each deviation. The District Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for requested deviations with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration
- B. Drawings showing general dimensions and confirming the size of equipment, fixtures, motors and drives, and piping connections.
- C. Testing Forms in accordance with industry standards. Submit example for engineer's approval.
- D. Testing, Adjusting and Balancing Report as specified in this Section.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the rules and regulations of Authorities Having Jurisdiction over the work specified herein, including all adopted state and local building codes including plumbing, mechanical, fire, building, and electrical.
- B. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

| Reference | Title |
|--------------------|--|
| AABC | Associated Air Balance Council, National Standards for Total System Balance |
| ASHRAE Standard 70 | Methods of Testing for Rating the Air Flow Performance of Outlets and Inlets |
| NEBB | National Environmental Balancing Bureau, Procedural Standards for Testing Adjusting and Balancing of Environmental Systems |

- C. Testing Agency: Procure the services of an independent air balancing and testing agency, belonging to the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB), to perform balancing, testing and adjustment of systems. One organization shall perform the testing and balancing services.
- D. Codes and Standards: Comply with applicable procedures and standards of the certification sponsoring association referenced above, in addition to the following:
 - 1. Calibration and maintenance of instruments and accuracy of measurements shall comply with the requirements of the standards.
- E. Special Requirements:
 - 1. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.
 - 2. Participate in verification of the testing and balancing report, which will consist of repeating measurements contained in the testing and balancing reports. Assist in diagnostic purposes when directed.
 - 3. Tests and adjustments shall include the complete testing and balancing of air systems and necessary adjustments to equipment to accomplish the specified design flow rates.
 - 4. Should any apparatus, material or work fail to meet the specified requirements in these tests, make the necessary corrections and retest the apparatus, material, or work at no additional cost to the District.
- F. Coordination:
 - 1. Coordinate the efforts of factory-authorized service Engineers for systems and equipment, odor control controls installers, and other mechanics to operate odor control systems and equipment to support and assist testing, adjusting, and balancing activities.
 - 2. Perform testing, adjusting, and balancing after leakage and pressure tests have been satisfactorily completed.
 - 3. Manufacturer's Instructions:
 - a. Follow manufacturer's written instructions.
 - b. If in conflict with Construction Documents, obtain clarification.
 - c. Notify the District's Engineer in writing before starting work.

G. Drawings:

1. Size of ductwork and pipes and general method of running them are shown, but it is not intended to show every offset and fitting nor every structural difficulty that may be encountered.

1.5 BALANCING

A. General: Characteristics to be tested and adjusted to conform to the values specified include the following:

1. Total airflow rates delivered by fans adjusted to SCFM.
2. Flow rates at all ducts adjusted to SCFM.
3. Flow rates across all dampers in foul air ductwork adjusted to SCFM.
4. Adjustment Tolerances
 - a. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design. Adjust outlets and inlets in space to within plus or minus 10 percent of design.
5. Airflow rates shall be obtained by adjustment of the fan speeds and/or dampers. All flow rates shall be measured with supply systems operating.
6. Flow rates at branch ductwork, and air distribution patterns shall be tested in strict accordance with ASHRAE Standard 70.

PART 2 - PRODUCTS

2.1 REPORT DATA

A. The final certified balancing report shall include the following actual field-verified data:

1. Equipment data:
 - a. Manufacturer and model, size, arrangement, class, location, and equipment number.
 - b. Motor horsepower, voltage, phase, and full load amperage.
 - c. Fan curves including ACFM, SCFM, Air Stream Temperature, Total static pressure, RPM, and operating motor BHP.
 - d. Differential pressure.
 - 1) Duct size, supply ACFM, SCFM, velocity, pressure measurements, and location of all measurements.

- 2) Differential pressure, inlet and outlet air temperatures at equipment.

B. Report Requirements:

1. Each individual final reporting form must bear the signature of the person who recorded the data and that of the supervisor of the reporting organization.
2. All instruments which were used shall be listed and identified including the last date each was calibrated.

C. Final Report: Final report shall be submitted prior to Supplier's request for final inspection. In addition to providing all specified data and information on applicable reporting forms, report shall include the following:

1. A schedule for testing and balancing parts of the systems which must be delayed due to seasonal, climatic, occupancy, or other conditions beyond control of the Supplier. Delayed work shall be completed as early as the proper conditions will allow, after consultation with the District.
2. Due to delayed testing, reports shall be submitted after execution of those services.
3. A total balance report shall include the following components:
 - a. General Information and Summary
 - b. Instrument Calibration
 - c. Air Systems
 - 1) Fan curves.
 - 2) Manufacturers' test data.
 - 3) Field test reports prepared by system and equipment installers.
 - d. Other information relative to equipment performance.
 - e. Record drawings with specified and measured flow rates

D. Complete apparatus report sheets for all air systems shall be accurately and completely filled out. The testing and balancing results shall be submitted on the TAB report forms of the applicable standard. Copies of the final test readings and report sheets shall be submitted in accordance with the Submittals section. A description of the standard procedures used during testing, adjusting, and balancing shall be included in the submittal. The submittal shall include a reduced set of drawings, with the air outlet devices, air inlet devices, and equipment

identified to correspond with the report sheets. Test dates shall be recorded on the individual TAB report forms indicating when the actual testing was performed.

E. The apparatus report sheets shall include the following information:

1. Title Page:

- a. Company name
- b. Company address
- c. Company telephone number
- d. Project name
- e. Project location
- f. Project Engineer
- g. Project Contractor
- h. Project altitude
- i. Date

2. Instrument List:

- a. Instrument
- b. Manufacturer
- c. Model
- d. Serial number
- e. Range
- f. Calibration date
- g. Equipment type/style (e.g., Rotating Vane anemometer)

3. Air Moving Equipment:

- a. Unit number
- b. Location
- c. Manufacturer
- d. Model and serial number

- e. Airflow, design and actual (SCFM)
 - f. Total static pressure (total external), design and actual
 - g. Static pressure, inlet and discharge
 - h. Total pressure
 - i. Fan RPM, design and actual
4. Electric Motors:
- a. Manufacturer
 - b. Motor type and frame
 - c. HP/BHP
 - d. Phase, voltage, amperage, nameplate, actual, no load.
 - e. RPM
 - f. Service factor
 - g. Starter size, rating, heater elements
5. V-Belt Drive:
- a. Required driven RPM
 - b. Driven sheave make, diameter, and RPM
 - c. Belt make, size, and quantity
 - d. Motor sheave make, diameter, and RPM
 - e. Center to center distance, maximum, minimum, and actual
6. Duct Traverse:
- a. System zone/branch
 - b. Duct size
 - c. Area
 - d. Velocity, design and actual
 - e. Airflow, design and actual (SCFM)
 - f. Duct static pressure

- g. Air temperature
 - h. Air correction factor
7. Sound Level Report:
- a. Location
 - b. Octave bands - equipment off
 - c. Octave bands - equipment on
8. Odor Control Vessels:
- a. Unit number
 - b. Manufacturer and model
 - c. Air pressure drop across media bed(s), design and actual
9. Mist Eliminators
- a. Manufacturer and model
 - b. Equipment served
 - c. Air pressure drop, design and actual

2.2 CERTIFICATE OF COMPLETION

- A. At completion of testing and balancing, Supplier shall submit a Certificate of Compliance stating that each apparatus, device, outlet, and system has been tested, adjusted, and balanced so that it is operating in conformance with manufacturers' recommendations and with the specified conditions.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Furnish all equipment, material, personnel, and supplies to perform the tests and make all taps and other necessary temporary connections.
- B. Field performance tests shall be conducted for each system to demonstrate each is functioning as specified and to the satisfaction of District's Engineer.
- C. All tests shall be conducted in a manner acceptable to District's Engineer and shall be repeated as many times as necessary to secure District's Engineer acceptance of each system.
- D. If inspection or tests indicate defects, the defective item or material shall be replaced, and the inspection and tests shall be repeated.

- E. All repairs to piping shall be made with new materials.
- F. Caulking of threaded joints or holes will not be acceptable.

3.2 INSPECTION

- A. Before testing and balancing the air system, fans shall be checked for correct rotation and rotative speed. Dampers shall be open and access doors and panels shall be closed during the testing and balancing period.

3.3 TESTING, TRAINING AND COMMISSIONING

- A. Prior to performance of Testing, Adjusting and Balancing work, provide copies of reports, sample forms, checklists, and certificates.
- B. Notify the District at least ten (10) days in advance of testing and balancing work, and provide access for the District to witness testing and balancing work.
- C. Provide technicians, instrumentation, and tools to verify testing and balancing of odor control systems.
- D. Following completion of testing and balancing the system shall be left in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.4 PERFORMANCE OF WORK

- A. General:
 - 1. Testing, adjusting, and balancing shall be performed after the system installation is complete but prior to acceptance of the project.
 - 2. Perform testing and balancing procedures on each system according to the procedures contained in AABC national standards or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
 - 3. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish. Coordinate with mechanical contractor to identify locations prior to insulation to avoid re-work
 - 4. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

B. Airflow System Measurements:

1. Measure and adjust foul air fans to deliver at least 100 percent of the design air volume.
2. Measure static air pressure conditions on fans, including pressure drops, and total pressure across the fan.
3. Adjust fan speeds and motor drives within drive limitations, for required air volume. Set a speed to provide air volume farthest distance from the fan without excess static pressure. Check amp draw of fans on initial startup. If running amps exceed nameplate, shut off motor immediately, notify District, and make necessary drive changes as directed.
4. Airflow rates shall be within plus or minus 5 percent of the design values specified.
5. Measure and adjust air dampers to deliver at least 100 percent of the design air volume. Measure static air pressure conditions on fans and total pressure across the fan.

C. Systems to be Balanced:

1. All foul air equipment and systems shall be balanced.

3.5 FINAL INSPECTION

- A. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, new reports submitted, and new inspection test made.
- B. Following acceptance of the reports by the District's Engineer, Supplier shall permanently mark all damper positions so that they can be restored to their correct position if disturbed at any time. Devices shall not be marked until after final inspection.

END OF SECTION

SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:

1. Division 26, Electrical, covers the work necessary for the complete electrical system. Furnish materials, labor, and equipment in accordance with these Specifications and the accompanying drawings.
2. Division 26, Electrical, in its entirety apply to all electrical work and equipment furnished on this project whether furnished or specified under this or other divisions of these Specifications.
3. Division 1, General Requirements, which contain information and requirements that apply to the work specified herein and are mandatory for this project.
4. Like items of materials provided hereunder shall be the end product of one manufacturer in order to achieve standardization for appearance, maintenance, and replacement.

1.2 QUALITY ASSURANCE

A. Codes and Standards

1. The components covered by these Specifications shall be designed, tested, assembled, and installed in accordance with the minimum requirements of the latest published standards of the California Electric Code (CEC), National Electrical Safety Code (NEC), Underwriters Laboratory (UL), American National Standard Institute (ANSI), Institute of Electrical and Electronic Engineers, Inc. (IEEE), and the National Electrical Manufacturers Association (NEMA).

B. Material and Equipment Qualifications

1. Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products, which are of equal material, design, and workmanship. Products shall have been in satisfactory industrial use for 10 years prior to bid opening. The 10 year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 10 year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacture; however, the component parts of the item need not be

the products of the same manufacturer unless stated in the technical section.

C. Alternative Qualifications

1. Products having less than a 10 year field service record will be acceptable if a certified record of satisfactory field operation for not less than 20,000 hours, exclusive of the manufacturer's factory or laboratory tests, is furnished.

D. Service Support

1. The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

E. Manufacturer's Nameplate

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

F. UL 508 Certification

1. All control panels furnished shall conform to the requirements of UL508A. A UL508A label shall be fixed to the panel door.
2. All control panels shall also conform to requirements per NEC Article 409- Industrial Control Panels and NFPA 79 Electrical Standard for Industrial Machinery.

G. Installer Qualifications

1. The installer shall be a firm that is regularly engaged the construction of industrial facilities. The installer shall be a licensed electrical contractor / subcontractor who is familiar and complies with the latest issues of National Electrical Code (NEC), California Electrical Code (CEC), and all State and local codes that pertain to installing electrical work. The installer shall also be familiar, and comply with, the standard requirements of the power and communications utilities in the area. The installer shall be familiar with NFPA 820 and the installation practices for classified locations.

H. Standards, Codes, Permits, and Regulations

1. Perform work; furnish, install, and test materials and equipment in full accordance with the latest applicable rules, regulations, requirements, and specifications of the following:
 - a. Local Laws and Ordinances
 - b. State and Federal Laws
 - c. California State Fire Marshal (CSFM)
 - d. California Fire Code (CFC)
 - e. Titles 8, 19, and 24 of the California Code of Regulations (CCR)
 - f. National Fire Protection Association (NFPA)
 - g. Underwriters' Laboratories (UL)
 - h. National Electrical Safety Code (NESC)
 - i. American National Standards Institute (ANSI)
 - j. National Electrical Manufacturer's Association (NEMA)
 - k. National Electrical Contractors Association (NECA) Standard of Installation
 - l. Institute of Electrical and Electronics Engineers (IEEE)
 - m. Insulated Cable Engineers Association (ICEA)
 - n. Occupational Safety and Health Act (OSHA)
 - o. National Electrical Testing Association (NETA)
 - p. American Society for Testing and Materials (ASTM)
 - q. California Electrical Code (CEC)
 - r. NFPA 70, National Electrical Code (NEC)
 - s. NFPA 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities
 - t. Electrical Testing Laboratories Inc (ETL)
2. Conflicts, if any that may exist between the above items will be resolved at the discretion of the Engineer.

3. Wherever the requirements of the specifications or drawings exceed those of the above items, the requirements of the specifications or drawings govern. Code compliance is mandatory. Construe nothing in the Contract Documents as permitting work not in compliance with these codes.
4. Obtain all permits and pay all fees required by any governmental agency or utility having jurisdiction over the work. Arrange all inspections required by these agencies. On completion of the work, furnish satisfactory evidence to the Engineer that the work is acceptable to the regulatory authorities having jurisdiction.

1.3 SUBMITTALS

A. General:

1. Provide manufacturers' descriptive information and shop drawings for all equipment, material, and devices furnished under Division 26, Electrical including certified outline and arrangement drawings, schematic (elementary) diagrams, interconnection, and connection diagrams, in accordance with Section 01 33 00, Submittals and this section. Device designations and symbols for schematic (elementary) connection or interconnection diagrams shall conform to the latest edition of NEMA ICS 1.
2. Submit complete interface schematic drawings for all equipment furnished in accordance with other Divisions (23, , 40, 43, etc.) that interface with electrical equipment. These drawings shall contain diagrams, terminal numbers, device names, tag numbers, control cable conductor colors and numbers, etc., to provide complete identification of the circuits and provide coordination between the equipment.
3. Manufacturer's standardized elementary diagrams will not be acceptable unless applicable portions of the diagram have been clearly identified and non-applicable portions deleted or crossed out.
4. Submittal shop drawing formats:
 - a. Shop drawings shall be submitted in accordance with Section 01 33 00.

B. Submit certified shop drawings and diagrams as follows:

1. Layouts indicating conformity with space requirements
2. Assembly drawings in sufficient detail to identify every part of the specified equipment including bills of material

3. Detailed panel, cubicle, and structure layout drawings showing the principal dimensions of the equipment, the location of all devices therein, and the size of electrical conduits and connections.
 4. One-line, three-line, schematic (elementary), connections detailing all internal wiring, and interconnection diagrams detailing all field wiring.
 5. Control schematics shall use the ladder diagram type format incorporating line number, operation function statement, contact location line number with an underline for a normally closed contact, a description of operation of each device and complete step-by-step written sequence of operation. Wire and terminal numbers shall be clearly shown. Actual device symbols shall be used to represent equipment such as limit switches, level switches, pressure switches, time delay relays, etc. Control schematics shall be shown with the electrical system in a de-energized state. Refer to the schematic (elementary) diagrams in the contract drawings for examples. Refer to District's Standard Drawing STD-E-001 for device symbols and General Notes. Each motorized equipment shall be provided with a control schematic diagram with equipment tag name. A typical motor control schematic shall not be allowed.
 6. Complete interconnection diagram for each system showing every wire by number, every junction terminal box or device to which it connects from origination to final destination, and boxes, manholes, pull boxes, and cabinets through which it passes. These diagrams shall show wiring installed by Contractor between items of manufactured, prewired, or non-prewired equipment.
 7. Furnish schematic (elementary) diagrams, including Contractor modifications, of all factory wired equipment and Contractor furnished equipment for District's approval and record purposes. These wiring diagrams shall indicate point-to-point wire terminations, and wire color identifications with tags per Section 26 05 19.
 8. Characteristic curves for all protective devices.
 9. Installation drawings for all electrical work showing conduit layout, conduit sizes and locations of equipment foundations, and details accurately dimensioned. Conduits located in foundation slabs or routed through concrete structures shall be indicated on the installation drawings and submitted for review prior to foundation concrete pour.
- C. Seismic requirements:
1. Submit anchorage calculations for equipment listed below and equipment that weighs 200 pounds or greater.

2. The following electrical equipment shall be seismically anchored:
 - a. W36-SL-DISC-01, W36-SL-VFD-01, and W36-HYD-FIC-01 pedestal
 - b. JBP4300 and JBS4300 pedestal
 - c. W36-HYD-DISC-01 and W36-HYD-CS-01 pedestal

1.4 RESPONSIBILITY

- A. The Contractor shall be responsible for:
 1. Complete system functionality in accordance with the intent of these Contract Documents.
 2. Coordinating the details of equipment layouts and construction for all Specification Divisions which affect the work covered under Division 26, Electrical.
 3. Furnishing and installing all incidental items not actually shown or specified, but which are required by good practice to provide a complete functional system.
 4. Coordination with Division 40, Process Integration, for installation of plant control system including but not limited to: field instrumentation, heat tracing, control networks and media converters, computers, and control panels. Also includes wiring requirements.

1.5 INTENT OF DRAWINGS

- A. The Contract drawings indicate the extent, general location, and arrangement of equipment. Duct bank and conduit runs are diagrammatic and may not show the exact locations for installation. The Contractor shall verify the locations of conduit stub-ups based upon conduit entry space of equipment furnished from the manufacturer's certified shop drawings and by inspection of the actual equipment to be installed.
- B. Where it is necessary to connect to existing equipment, the existing equipment has been located as accurately as possible from record drawings. Exact location is not guaranteed. The contractor shall inspect existing conditions and determine exact locations as required. Variations from locations indicated will not be basis for additional compensation.
- C. Existing underground equipment and piping in public areas and in the vicinity of work, including electric, communication, gas, water, etc. owned by other utilities/agencies shall be carefully verified and inspected prior to performing work. All equipment installations shall be in compliance with the requirements in accordance with the existing utilities in the vicinity of work.

- D. In general, items shown on electrical drawings in black indicate electrical work under this construction contract. Items that are screened are existing facilities. Items in lighter line weight black typically refer to work under this construction contract under a different discipline.
- E. Standard details are typical for all locations which apply regardless of whether a callout is shown on the plan or not.
- F. Electrical design is based on minimum horsepower and current ratings. If the manufacturer or Contractor provides equipment with a larger horsepower or current rating, the Contractor shall be responsible for making all necessary changes to accommodate the larger unit, with the approval of the Engineer. Contractor shall pay for all such changes including engineering design by a Professional Electrical Engineer currently registered in the State of California with an active license.
- G. Number and size of wires which shall be installed in runs of conduit where not shown on the drawings shall be determined from the one line, schematics, connection, interconnection, conduit schedule, and control diagrams of actual equipment furnished.

1.6 DEFINITIONS (APPLICABLE TO SPECIFICATIONS AND DRAWINGS)

- A. Certified: Confirmed to be accurate, or as represented, or as meeting standards.
- B. Concealed: Inside building above grade and located within walls, furred spaces, crawl spaces, attics, above suspended ceiling, etc. In general, any item not visible or directly accessible.
- C. Connect: Complete hookup of item with required services, including conduits, wires, and other accessories.
- D. Exposed: Either visible or subject to mechanical or weather damage, indoor or outdoor, include areas such as mechanical and storage rooms. In general, any item that is directly accessible without removing walls, panels, ceilings, or other parts of structure.
- E. Furnish: Supply and deliver complete.
- F. Install: Place, secure and connect as required to make fully operational.
- G. Provide: Furnish and install as defined above: perform work.
- H. Use (verb): Furnish and install as defined above.
- I. Wiring: Electrical conduit, raceway, conductors, and connections.

1.7 SUBSTITUTION OF MATERIALS AND EQUIPMENT

- A. Make requests for approval of alternatives in writing to the Engineer before submittals of shop drawings. Provide sufficient material or data to allow evaluation of the proposed alternative and determination of compliance with these Contract Documents. List any proposed deviations from these Contract Documents.

1.8 ELECTRICAL INSTALLATIONS

- A. Electrical installations shall conform to ANSI C2, NEC, CEC, and requirements specified herein, and in the sections specifying the associated equipment materials, and systems. The most stringent code shall be followed.
- B. Wiring and Conduit: Provide internal wiring for components of packaged equipment as an integral part of the equipment, where such wiring is not provided by the equipment manufacturer. Provide power, control, instrumentation and data wiring and conduit for field-installed equipment and wiring systems. A final set of drawing shall be included in all panels. Drawings shall depict schematics of field as-built conditions. Drawings shall be drafted in the AutoCAD format and printed in 11" x 17" size.

1.9 LOCKOUT REQUIREMENTS

- A. Provide disconnecting means, capable of being locked out, for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with applicable requirements of CAL OSHA and Title 8 of the California Code of Regulations. All local disconnects shall be rated as shown on Contract Drawings.

1.10 ELECTRICAL CHARACTERISTICS

- A. Electrical characteristics for this project shall as specified in Contract Drawings. Final connections to the new equipment provided under this contract shall be in accordance with the manufacturer's recommendations. Final connections to the existing power distribution system shall be made to match existing condition or specified in the contract documents.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Unless otherwise indicated, provide all first quality, new materials, and equipment, free from any defects, in first class condition, and suitable for the space provided. Provide UL listed materials and equipment wherever standards have been established by that agency.
- B. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer.

2.2 STANDARD PRODUCTS

- A. Unless otherwise indicated, provide materials and equipment which are the standard products of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturers' latest standard design that conforms to these Specifications.

2.3 EQUIPMENT FINISH

- A. Provide materials and equipment with manufacturers' standard finish system. Provide ANSI 61, light grey color or RAL 7035 (light gray) with Electrostatic Powder for all equipment unless otherwise specified in the individual equipment sections. Provide two quarts of touchup paint.
- B. Provide standard manufactures brush finish for all stainless steel NEMA 4X enclosures.

2.4 ENVIRONMENTAL

- A. Provide materials and equipment suitable for installation and operation under rated conditions at 200 feet above sea level and with maximum ambient temperature of 140°F (60°C).

2.5 OUTDOOR EQUIPMENT

- A. Provide equipment and devices to be installed outdoors or in unheated enclosures capable of continuous operation within an ambient temperature range of 32°F to 140°F. Equipment must be capable of proper operation at rated output continuously in this ambient temperature range in direct sun. Provide additional equipment such as enclosures, sunshades, and cooling equipment so that this performance requirement can be met.

2.6 FASTENERS

- A. Fasteners for securing equipment to walls and floors shall be stainless steel.

2.7 ENCLOSURES

- A. General
 - 1. Equipment enclosures shall have NEMA ratings suitable for the location in which they are installed, as specified in this Section, or as shown on the drawings.
- B. Electrical enclosures shall have the following ratings:
 - 1. NEMA 4X. Stainless steel Type 316 NEMA 4X enclosures shall be used in all outdoors locations and indoor wet locations. Doors or covers shall be attached with 316 stainless steel continuous hinge. The cover-to-box joint shall be made watertight with a mechanically retained gasket.

2. Acceptable Manufacturers:
 - a. Eaton.
 - b. Hoffman.
 - c. Or equal.

PART 3 - EXECUTION

3.1 GENERAL

- A. Unless specified otherwise, electrical equipment and anchoring systems shall be designed to withstand seismic forces as specified in Section 01 43 11.
- B. Install materials and equipment in a workmanlike manner utilizing craftsmen skilled in the particular trade. Provide work which has a neat and finished appearance. Carry out work in accordance with NECA Standard of Installation unless otherwise specified.
- C. Coordinate electrical work with the Engineer, with other trades, and work with various agencies and/or utilities to avoid conflicts, errors, delays, and unnecessary interference with operation of the plant during construction.
- D. Check the approximate locations of light fixtures, electrical outlets, equipment, underground utilities, and other electrical system components shown on drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify and provide recommended solution to the Engineer in writing. The Engineer's decision shall govern. Make modifications and changes required to correct conflicts.
- E. In general, coordinate and notify District at least two weeks prior to all demolition work. Clean the equipment and the area prior to re-use the equipment and when the new work is in the same area.
- F. When conduit is removed, watertight seal, cap-off, and cover all conduit openings of all equipment including wall, control panel, junction box, pull box, T-Fittings, etc that remain. In Classified area, cap-off shall be gastight with at least 5 thread count cap.

3.2 PROTECTION DURING CONSTRUCTION

- A. Throughout this Contract, provide protection for materials and equipment against loss or damage in accordance with provisions elsewhere in these Contract Documents. Throughout this Contract, follow manufacturers' recommendations for storage. Protect everything from the effects of weather. Prior to installation, store items in clean, dry, and indoor locations to prevent condensation. Energize all space heaters furnished with equipment or provide temporary heating, sufficient to prevent condensation, in transformers, switchgear, motors, motor control centers, and motor starters which do not have space heaters.

- B. Following installation, protect materials and equipment from corrosion, physical damage, and the effects of moisture on insulation. When equipment intended for indoor installation is installed at the Contractor's convenience in areas where it is subject to dampness, moisture, dirt, or other adverse atmosphere until completion of construction, ensure that adequate protection from these atmospheres is provided that is acceptable to the Engineer. Cap conduit runs during construction with manufactured seals. Keep openings in boxes or equipment closed during construction. Energize all space heaters furnished with equipment. Cap all spare conduits with pull rope.
- C. The Contractor shall provide electrical insulating blankets to create a barrier between potentially energized conductors and workers when working in a confined space.

3.3 MATERIAL AND EQUIPMENT INSTALLATION

- A. Follow manufacturers' installation instructions explicitly, unless otherwise indicated. Wherever any conflict arises between the manufacturers' instructions, codes and regulations, and these Contract Documents, follow Engineer's decision. Keep copy of manufacturers' installation instructions at the jobsite for review at all times.
- B. Use appropriate conduit and conductor fittings that maintain the specified enclosure environmental ratings after proper installation.

3.4 EQUIPMENT SUPPORTS

- A. Provide equipment supports for all equipment in accordance with the manufacturer's requirements. Free standing panels and enclosures shall be mounted on concrete pads that are of the same plan dimensions as the equipment furnished unless otherwise shown on the drawings. Provide leveling channels under all equipment with roll out or draw out circuit breakers or contactors, located as recommended by the equipment manufacturer.

3.5 CUTTING AND PATCHING

- A. Lay out work carefully in advance. Do not cut, drill, or notch any structural member or building surface without specific approval of Engineer. Carefully carry out any cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Prior to drilling through walls, floors, or any concrete slab member, perform non-destructive x-ray to locate supporting rebar. Following such work, restore surfaces neatly to original condition. Use only skilled craftsmen of the trades.

3.6 CLEANING AND TOUCHUP PAINTING

- A. Keep the premises free from accumulation of waste material or rubbish. Upon completion of work, remove all materials, scraps, and debris from premises and from interior and exterior of all devices and equipment. Touch up scratches, scrapes, or chips in interior and exterior surfaces of devices and equipment with finishes matching as nearly as possible the type, color, consistency, and type of surface of the original finish. If extensive damage is done to equipment paint surfaces, refinish the entire equipment in a manner that provides a finish equal to or better than the factory finish, that meets the requirements of the Specifications, and that is acceptable to the Engineer.
- B. The interior of all electrical equipment, including windings of dry type transformers, shall be vacuumed, and wiped free of dust just before final acceptance. De-energization of equipment shall be at times approved in writing by the Engineer.

3.7 INSPECTION

- A. Allow materials, equipment, and workmanship to be inspected at any time by the Engineer and District or their representatives. Correct work, materials, or equipment not in accordance with these Contract Documents or found to be deficient or defective in a manner satisfactory to the Engineer.

3.8 SERVICE CONTINUITY

- A. Maintain continuity of electric service to all functioning portions of the plant. Make no outages without prior written authorization of the Engineer. Include all costs for temporary wiring and overtime work required in the Contract price. Remove all temporary wiring at the completion of the work. Refer to Section 01 35 13 for additional requirements.
- B. Coordinate MCC shutdown for any bucket replacement or bucket modifications.

3.9 TEMPORARY ELECTRIC POWER

- A. Refer to Section 01 50 00 for necessary provisions for electric power used during construction.
- B. The Contractor shall provide temporary lighting for all trades within the buildings. The average lighting level (footcandle) shall meet OSHA and CALOSHA requirements.

3.10 TESTS

- A. Perform testing as specified in Sections 01 75 17 and 26 08 00.

3.11 JOB SAFETY BRIEFING

- A. Prior to the start of the project, conduct a joint District and Contractor job safety briefing to cover hazards associated with the job, work procedures involved, energy source controls, and associated special precautions.
- B. Provide a record of the meeting and attendance to the Engineer within five (5) days after the briefing.

END OF SECTION

SECTION 26 05 19

LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work Included: This section covers the work necessary to provide a complete and operable low voltage cable system as specified herein.
- B. Specialty cables for telecom, data networking, and other similar systems are covered in the specification for that system.
- C. Related Sections: Refer to other divisions and sections of these specifications to determine the extent and character of related electrical work specified elsewhere, but which shall be done under this section.
 - 1. Section 01 33 00 – Submittal Procedures
 - 2. Section 26 05 00 – Common Work Results for Electrical
 - 3. Section 26 05 26 – Grounding and Bonding for Electrical Systems
 - 4. Section 26 05 53 – Identification of Electrical Systems
 - 5. Section 26 08 00 – Commissioning of Electrical Systems

1.2 SUBMITTALS

- A. Make submittals in accordance with Section 01 33 00 Submittal Procedures, and Section 26 05 00 Common Work Results for Electrical. In addition to these requirements, submit the following:
 - 1. Perform cable insulation and resistant tests in accordance with the NETA ATS latest version.

1.3 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. B-3 - Standard Specification for Soft or Annealed Copper Wire.
 - 2. B-8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - 3. B-33 – Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes

- B. American National Standards Institute (ANSI):
 - 1. C2 - National Electrical Safety Code
- C. Institute of Electronic and Electrical Engineers (IEEE):
 - 1. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
 - 2. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
- D. Insulated Cable Engineers Association (ICEA):
 - 1. S-73-532 – Standard for Control, Thermocouple Extension and Instrumentation Cables. (Join Standard NEMA WC 57)
 - 2. S-95-658 – Standard for Non shielded Power Cables rated 2000 Volts or less. (Joined Standard NEMA WC 70)
- E. National Fire Protection Association (NFPA):
 - 1. NFPA 70 – National Electrical Code
- F. National Electrical Manufacturers Association (NEMA):
 - 1. WC 26 – Wire and Cable Packaging
- G. InterNational Electrical Testing Association (NETA ATS)
- H. Underwriters Laboratory (UL):
 - 1. Standard 44 – Thermoset Insulated Wires and Cables
 - 2. Standard 83 – Thermoplastic Insulated Wires and Cables
 - 3. Standard 486A/486B – Wire Connectors
 - 4. Standard 510 – Polyvinyl Chloride, Polyethylene and Rubber Insulating Tapes
 - 5. Standard 1063 – Machine Tool Wires and Cables
 - 6. Standard 1581 – Reference Standard for Electrical Wires, Cables and Flexible Cords

1.4 SYSTEM DESCRIPTION

- A. The application for required cable, wire, and connectors include, but are not limited to:
1. Power distribution circuitry
 2. Lighting circuitry
 3. Appliance and equipment circuitry
 4. Network and communication systems and circuitry
 5. Wiring for motors of mechanical equipment
 6. Wiring from the motor(s) of mechanical equipment to disconnect switches or junction boxes, control panels, including wiring for pushbuttons, pilot lights, interlocks and similar devices as directed, shown, or specified.
 7. Wiring from the motors of mechanical equipment to motor starters, including other auxiliary wiring as may be required, directed, or shown.
 8. Line voltage wiring as required by other Disciplines, and interlocking to motor starters
 9. Control wiring for motors, mechanical equipment, relays and switches, and similar mechanical-electrical devices.
 10. Line voltage wiring to thermostats, alarm system components, security system components and other miscellaneous equipment

1.5 CONDUCTOR COLOR CODING

- A. Color coding of multiconductor control and instrumentation cable is specified in the individual cable type specification.
- B. For power conductors, provide all single conductors and individual conductors of multiconductor power cables with integral insulation pigmentation of the designated colors, except conductors larger than No. 6 AWG may be provided with color coding by wrapping the conductor at each end and at all accessible locations with vinyl tape. Where this method of color coding is used, wrap at least six full overlapping turns of tape around the conductor covering an area 1-1/2 to 2 inches wide at a visible location at all conductor termination and pulling points.
- C. Phases A, B, C imply the direction of positive phase rotation.

D. Use the following colors:

| <u>System</u> | <u>Conductor</u> | <u>Color</u> |
|---|----------------------------|----------------------------------|
| All Systems | Equipment Grounding | Green |
| 208Y/120 Volts, 3-Phase, 4-Wire | Grounded Neutral | White |
| | Phase A | Black |
| | Phase B | Red |
| | Phase C | Blue |
| 480Y/277 Volts, 3-Phase, 4-Wire | Grounded Neutral (if used) | White, Black Tracer |
| | Phase A | Brown |
| | Phase B | Orange |
| | Phase C | Yellow |
| Single Conductor, AC | | Red |
| Multiple Conductor Control Cables | | ICEA Method 1 Table E-2 |
| Multiple Conductor Power Cables | | ICEA Method 1 or 3, Table E-2 |
| 12 or 24V DC Positive | | Blue |
| 0V DC | | Blue with Gray Stripes |
| Single-Conductor, DC Alarm, Annunciator, Instrumentation, and Telemetry (if not shielded) | | Purple |

E. All conductors carrying AC foreign voltage over 100 VAC into control panels, switchboards, and other enclosures shall be yellow. Multi-conductor cables carrying such foreign voltage shall be marked with yellow tape at each termination point.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Storage of cable after pulling or splicing shall include purging of entire cable with nitrogen or otherwise seal with tape at both ends.
- B. Inspect the reels as they are unloaded from the delivery truck. Any visible damage shall be reported by the Contractor and the reel returned to the factory.

- C. Provide a crane, special lift truck or forklift to unload the cable reels.
- D. Cables shall be packaged on spools or reels. Each package shall contain only one continuous length of cable. Construct the packaging so as to prevent damage to the cable during shipping and handling.
- E. All conductor ends shall be sealed at the factory, and these seals shall be intact when the conductors are delivered.

PART 2 - PRODUCTS

2.1 GENERAL

- A. The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired only. Products of other manufacturers will be considered in accordance with the Division 01, General Requirements.

2.2 CONDUCTORS

- A. Provide cables as specified under the number type in this section (Type 1, Type 2, etc.). Conduits shown on the drawings have been sized to accommodate the outside diameter for each type.
- B. Multi-Conductor Power, Control, and Instrumentation Cable 600 Volts and Less:
 - 1. Provide cable that is UL listed and conforms to the requirements of UL 1277 and CEC Article 340, or UL listed Power Limited Circuit Cable that conforms to the requirements of Article 725 of the National Electrical Code. Provide cables permanently and legibly marked with the manufacturer's name, the nominal voltage, the type of cable, and the UL label (or submit evidence of UL listing).
 - 2. Type 10 (600-Volt, Twisted, Shielded Pair Instrumentation Cable):
 - a. General: Type TC, single pair instrumentation cable designed for noise rejection for process control, computer, or data log applications. Suitable for installation in conduit, wireway, or other approved raceways. Minimum cable temperature rating shall be 90 degrees C dry locations, 75 degrees C wet locations.
 - b. Individual Conductors: No.18 AWG stranded bare annealed copper, Class B, 7strand concentric per ASTM B8, size as indicated on the drawings; 7strand tinned copper drain wire.
 - c. Insulation and Jacket: Each conductor 15mil nominal PVC and 4mil nylon insulation. Pair conductors pigmented black and red. Jacket flame retardant and sunlight and oil resistant PVC with 45 mil nominal thickness. Aluminum/polyester shield overlapped to provide 100 percent coverage.

- d. Acceptable Manufacturers:
 - 1) Belden No. 9341.
 - 2) Okonite Okoseal-N Type P-OS.
 - 3) Dekoron 1C52.
 - 4) General Cable, VNTC, Spec 2450
 - 5) Or equal.
- C. Type 11 (Power and control cables 600 Volts and less):
 1. Unless otherwise indicated, provide stranded conductors.
 2. Provide the following types of insulation:
 - a. Type XHHW-2 insulation for conductors No.14 and larger.
 3. Single conductor control wiring shall be No.14 AWG and shall have insulation type XHHW-2 and Class B stranded per ASTM B-8. Insulation shall be in accordance with ICEA S-95-658, NEMA WC-70, and UL listed.
 4. XHHW-2 power conductors shall have a cross linked polyethylene insulation rated at 90 degrees C in wet and dry locations.
 5. Provide copper conductors. Do not provide conductors smaller than those indicated.
 6. Acceptable Manufactures:
 - a. Southwire, SIMpull Type XHHW-2
 - b. Okonite, X-Olene Type XHHW-2
 - c. Or equal.
- D. Type 28 (VFD Cable 2000V Minimum)
 1. For installation between VFD and motor
 2. Three stranded XLPE insulated circuit conductors with one full sized insulated PVC ground.
 3. Jacket shall be oil resistant PVC type.
 4. 100 percent overall shield and 85 percent braid coverage

5. Provide cable that is UL listed and conforms to the requirements of UL 1277 Type TC-ER per CEC Article 336.
 6. Acceptable Manufacturers:
 - a. General Cable, CVTC, Spec 4575
 - b. Belden
 - c. Or equal.
- E. Type 14 (600-Volt Multi-twisted Shielded Pairs with a Common Overall Shield Instrumentation Cable):
1. General: Type TC, twisted, shielded pairs of instrument cables, grouped in a single cable, designed for use for instrumentation, process control, and computer applications. Suitable for installation in conduit, wireway, or other approved raceways. Minimum cable temperature rating shall be 90 degrees C dry and wet locations.
 2. Conductors: No. 18 stranded bare annealed copper, Class B, 7-strand, concentric per ASTM B8. Tinned copper drain wires sized as shown on the drawings, one for each pair and one for the overall group.
 3. Insulation and Jacket: Each conductor 15mil PVC and 4mil nylon insulation. Pair conductors pigmented black and red or black and white, with red or white conductor numerically printed for group identification. Outer jacket flame retardant and sunlight and oil resistant PVC with 45 mil minimum thickness. Individual pair shield aluminum/polyester. Group shield aluminum/polyester, overlapped for 100 percent coverage.
 4. Acceptable Manufacturers:
 - a. Belden No. 1048A (2 pairs), 1049A (4 pairs), 1050A (8 pairs).
 - b. Okonite Okoseal-N Type SP-OS.
 - c. Dekoron 1C74.
 - d. General Cable, VNTC, Spec 2500
 - e. Or equal.
- F. Type 14a (600-Volt Multi-twisted Shielded Pairs with a Common Overall Shield Instrumentation Cable and Armored Sheath):
1. Same as Type 14 with the additional features:
 - a. Classification: ITC/PLTC instrumentation tray cable.

2. Acceptable Manufactures:
 - a. 3M 35 Scotch Vinyl Electrical Tape for Color Coding
 - b. Plymouth Rubber Company Premium 37 Color Coding Tape
 - c. Or equal.

- I. Low Voltage Splices, 600 volts and below:
 1. General: Provide low voltage splices consisting of 600-volt compression type connectors and connector insulators, suitable for indoor and outdoor field installations.

 2. Provide two-way, uninsulated, compression connectors, long barrel type, suitable for use with stranded copper conductors. Provide UL listed connectors rated 600 volts minimum.
 - a. Acceptable Manufacturers:
 - 1) Burndy
 - 2) Thomas and Betts
 - 3) Panduit
 - 4) Or equal.

 3. For 480V and below applications, connector insulators shall be cold shrink type factory expanded and assembled tubular rubber sleeves, suitable for field installation including direct buried, overhead, and outdoor applications. Insulators shall shrink over in-line connections, forming a water-proof seal. Provide insulators rated for 1000 volts, minimum, with -40-to-194-degree F temperature rating and ANSI C119-1 compliance.
 - a. Acceptable manufacturers:
 - 1) 3M 8420 and 8430 Series for wires size #8 or larger, 3M Scotchcast 72-N Series for wire sizes #22-10.
 - 2) Or equal.

PART 3 - EXECUTION

3.1 GENERAL

- A. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii. Where pulling compound is used, use only UL listed compound compatible with the cable outer jacket, voltage rating, and with the raceway involved.
- B. Perform pulling of cable in such a manner that the cable outer jacket does not scrape against the edge of the conduit, at both the inlet and outlet ends of the conduit. Cable shall be free of sandy or gritty material during pulling. If cable is laid on ground during pulling, cable shall be wiped free of sandy or gritty material prior to entry of cable into conduit and prior to application of any pulling compound.
- C. Tighten all screws and terminal bolts using torque type wrenches and/or drivers to tighten to the inch-pound requirements of the CEC and UL.
- D. Where single conductors and cables in manholes, handholes, vaults, and other indicated locations are not wrapped together by some other means such as arc and fireproofing tapes, bundle throughout their exposed length all conductors entering from each conduit with nylon, self-locking, releasable, cable ties placed at intervals not exceeding 18 inches on centers.
- E. Terminate no more than two control conductors per terminal point. Terminate all spare conductors on terminal blocks.
- F. Low voltage power and control conductors shall be in separate conduits.
- G. Only combine conductors with no more than two wire sizes difference to prevent possible installation damage to the smaller conductors; otherwise use separate conduits.

3.2 CONDUCTOR 600 VOLTS AND BELOW

- A. Provide conductor sizes indicated on drawings with no splices except as accepted in writing by the Engineer.
- B. Wire nuts may be used on 120-volt lighting and 120-volt receptacle circuits only. Place no more than one conductor in any single-barrel pressure connection. Use crimp connectors with tools by same manufacturer and/or UL listed for connectors of all stranded conductors.
- C. Soldered mechanical joints insulated with tape will not be acceptable.

- D. Color coding on wire sizes larger than No. 6 AWG shall be by taping the individual conductors with the appropriate colored self-adhesive vinyl electrical tape. Vinyl plastic insulating tape for wire and cable splices and terminations shall be flame retardant, 7-mil thick minimum, rated for 105 degrees C minimum meeting the requirements of UL 510.
- E. Provide terminals and connectors acceptable for the type of material used.
- F. Arrange wiring inside control panels, motor starters, switchgear, etc., neatly cut to proper length, remove surplus wire, and braid and secure in an acceptable manner. Identify all circuits entering switchgear, motor starters, control panels, etc., in accordance with the cable schedules on the drawings. Terminate cable conductors on the same side of the terminal blocks as shown on the drawings.
- G. Terminate control and instrumentation wiring with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions. Where terminals provided will accept such lugs, terminate all control and instrumentation wiring (except solid thermocouple leads) with insulated, locking-fork compression lugs, Thomas & Betts Sta-Kon, or equal. Control panel incoming field wireway sizes indicated on the drawings are considered minimum. Contractor shall adjust wireway sizes to meet CEC percentage fill requirements.
- H. For terminals designed to accept only bare wire compression terminations use only stranded wire, and terminate only one wire per terminal. Tighten all terminal screws with torque screwdriver to the recommended torque values.
- I. Attach compression lugs with a tool specifically designed for that purpose which provides a complete, controlled crimp where the tool will not release until the crimp is complete. Use of plier type crimpers is not acceptable.
- J. Cap spare conductors and conductors not terminated with UL listed end caps. Label spare conductors with "From A – B, Spare – X" where A and B indicate the source and destination locations respectively and X shall be the unique spare sequence number.
- K. Where conductors pass through holes or over edges in sheet metal, remove all burrs, chamfer all edges, and install bushings and protective strips of insulating material to protect the conductors.
- L. For conductors that will be connected by others, provide at least 6 feet spare conductor in freestanding panels and at least 2 feet spare in other assemblies. Provide additional spare conductor length in any particular assembly where it is obvious that more conductor length will be needed to reach the termination point.
- M. Train cables passing through all manholes and handholes along the walls on cable racks. Allow minimum 5 feet of slack in each run in a "drip loop" at least once along a wall. Loops and cables shall be organized, trained, and neatly installed.

- N. Do not strip cables more than eight inches from the nearest termination point of that cable.
- O. Bundle and label all spare pairs with the cable designation. Tag all individual pairs to enable identification of spare pairs when making future terminations.
- P. Splices will not be permitted except as accepted in writing by the Engineer.
- Q. Ends of cable shall not be exposed to environment more than 24 hours after pulling or splicing. After 24 hours purge the cable with nitrogen or sealed with tape.
- R. All hardware used shall be minimum rated for grade #5.
- S. Used only rated compression lugs for all conductor terminations.

3.3 MULTI-CONDUCTOR POWER, CONTROL, AND INSTRUMENTATION CABLES 600 VOLTS AND LESS

- A. Splices will not be permitted except as accepted in writing by the Engineer.
- B. Where connections of cables installed under this section are to be made under Div. 40, Process Integration, leave pigtails of adequate length for neat, bundled type connections.
- C. Maintaining the integrity of shielding of instrumentation cables is essential to the operation of the control systems. Take special care in cable installation to ensure that grounds do not occur because of damage to the jacket over the shield. Shields shall be grounded at one location only as shown on the drawings.

3.4 LACING OF WIRES AND CABLES

- A. Lace all wires and cables in pull or junction boxes, manholes, handholes, wireways, and at each termination. Lace wires and cables so that the wires of the individual circuits are laced together by circuit and the laced-together circuit or cable shall be tagged with the cable number. Bundle all wiring entering and exiting the control panels into groups. Bundle and lace power, lighting, control, alarm, annunciator, and instrumentation wiring as specified herein.

3.5 FIELD QUALITY CONTROL

- A. Provide acceptance testing of all of the low voltage cables per Section 26 08 00.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included

1. Furnish all labor, materials, equipment and incidentals required and install a complete grounding system in strict accordance with Article 250 of the California Electrical Code (CEC), as shown on the drawings and as specified herein.
2. All raceways, conduits and ducts shall contain equipment grounding conductors sized in accordance with the CEC. Minimum sizes shall be No. 12 AWG.
3. Provide grounding bus bars and conductors where shown on the drawings.

B. Related sections

1. Section 01 33 00 – Submittal Procedures
2. Section 01 35 24 – Project Safety Requirements
3. Section 26 05 00 – Common Work Results for Electrical
4. Section 26 05 19 - Low Voltage Electrical Power Conductors and Cables
5. Section 26 05 33 - Raceways and Boxes for Electrical Systems
6. Section 26 05 53 – Identification of Electrical Systems
7. Section 26 08 00 – Commissioning of Electrical Systems

1.2 QUALITY ASSURANCE

- A. All grounding and bonding products shall be UL listed.
- B. All exothermically welded or compression-type terminal lugs for buried or embedded connections shall use materials qualified in accordance with IEEE 837.
- C. The individual or firm conducting the Schlumberger 4pin soil resistivity pre construction testing shall have a minimum of 10 years of experience performing Wenner or Schlumberger 4-pin soil resistivity testing in electric power utility right-of-way AC interference applications with dielectrically-coated pipelines. Provide references from a minimum of three projects.

- D. The individual or firm conducting the field acceptance testing for any components associated with pipeline grounding shall have a minimum of 10 years of experience designing, installing, and testing grounding systems. The lead individual responsible for field acceptance testing shall be a registered professional electrical or corrosion (grandfathered) engineer in California. Persons actually performing testing work shall have minimum NACE CP-2 (technician level) certification. Provide references from a minimum of three projects for all crew members.

1.3 SUBMITTALS

- A. Submittals shall be made in accordance with Section 01 33 00, Submittal Procedures, and Section 26 05 00, Common Work Results for Electrical. In addition to these requirements, provide the following:
1. Shop drawings
 - a. Submit installation drawings showing locations of buried ground rods, grounding connections, locations of embedded and buried grounding conductors, ground test stations, and locations of stub-ups and pigtailed for future connections to the grounding system.
 - b. Submit as-built drawings of the grounding system installation.
 - c. All drawings shall be dimensioned and include reference points, northing/easting coordinates, stationing, and other similar information necessary to locate buried and/or concealed grounding system infrastructure in the future.
 2. Grounding field acceptance testing:
 - a. Qualifications of the individual or firm conducting the field acceptance testing.
 - b. List of proposed testing equipment and current calibration data.
 - c. Proposed field acceptance test procedures.
 3. As-built documents and Operation and Maintenance (O&M) manuals per the requirements of Section 01 33 00.

1.4 REFERENCES

- A. American California Standards Institute (ANSI)/ Institute of Electrical and Electronics Engineers (IEEE)
1. IEEE Std 142 – IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems.

- B. American Society for Testing and Materials (ASTM)
 - 1. B 3 – Standard Specification for Soft or Annealed Copper Wire.
 - 2. B 187 – Standard Specification for Copper Bar, Bus Bar, Rod, and Shapes.
 - 3. B 8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - 4. B 418-95a Type II – Standard Specification for Cast and Wrought Galvanic Zinc Anodes.
- C. California Code of Regulations
 - 1. Title 24, Part 3 – California Electrical Code (CEC), Article 250 (Grounding).
- D. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE Std 80 – IEEE Guide for Safety in AC Substation Grounding.
 - 2. IEEE Std 837 – IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding.
- E. Underwriters Laboratories (UL)
 - 1. 467 – UL Standard for Grounding and Bonding Equipment.
 - 2. 224 – UL Standard for Extruded Insulating Tubing.
- F. Canadian Standards Association (CSA)
 - 1. CAN/CSA-C22.3 No. 6-M91 – Principles and Practices of Electrical Coordination Between Pipelines and Electric Supply Lines.
- G. InterNational Electrical Testing Association (NETA)
 - 1. ATS – Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

1.5 DESIGN CRITERIA

- A. Equipment grounding conductor sizing
 - 1. Include a Type 11 insulated copper ground wire as specified in Section 26 05 19 in every power conduit or multi-conductor cable that supplies power to motors. The ground cable shall be the same size as the power cable up to size 2 AWG. After 2 AWG, the ground may be reduced to half the size of the power cable as long as 2 AWG is the smallest size selected when the ground cable is smaller than the power cable.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Direct-buried, concrete encased, and exposed grounding conductors
 - 1. Bare concentric stranded copper conductors conforming to ASTM B-8 with Class B stranding, size as indicated on the drawings.
 - 2. Acceptable manufactures:
 - a. Southwire
 - b. General Cable
 - c. Or equal.

- B. Ground rods
 - 1. 3/4-in by 12-ft copper clad steel constructed in accordance with UL 467. The copper thickness shall be 13 mil minimum, 15 mil average. Provide UL mark on ground rod.
 - 2. Acceptable manufacturers:
 - a. Eritech (Erico)
 - b. Harger
 - c. Or equal.

- C. Conduit grounding bushings
 - 1. Insulated, 150 degree Celsius, malleable iron type with a solderless set-screw lug.
 - 2. Acceptable manufacturers:
 - a. Appleton
 - b. Hubbell Electrical Products (Raco)
 - c. Or equal.

D. Grounding system connections:

1. Buried or inaccessible connections

a. Make buried or inaccessible grounding connections with exothermic welds. Molds, cartridge materials, and accessories shall be as recommended by the manufacturer of the molds for the items to be welded. Molds and powder shall be furnished by the same manufacturer.

b. Acceptable manufacturers:

- 1) Erico (Cadweld)
- 2) Harger (Ultraweld)
- 3) Or equal.

2. Accessible connections to equipment, connections to structural steel, connections to reinforcing steel

a. Make mechanical connections to equipment, structural steel, and other accessible connections using one or two hole compression copper lugs as required for the cable size specified.

b. Make mechanical connections to reinforcing steel using UL 467 listed irreversible crimp compression copper connectors with the “run” and “tap” sizes as required for the reinforcing steel and cable size, respectively, specified. Connectors shall be factory prefilled with moisture inhibiting compound.

c. Acceptable manufacturers:

- 1) Harger
- 2) Burndy
- 3) Or equal.

E. Pre-cast concrete boxes for ground-rod installation

1. Provide where shown on the drawings. Provide H-20 traffic rated lids inscribed “Ground Rod” on the top.

2. Acceptable manufacturers:

- a. Old Castle / Christy
- b. Jensen Precast

- c. Or equal.
- F. Ground test station (GTS)
- 1. Each GTS shall be an assembly consisting of the following components:
 - a. 1/4" thick solid copper ground bar with length and height of bar sized per the number of connections required. The bar shall include pre-drilled universal lug holes.
 - b. 600V insulators
 - c. Wall mounting bracket and all necessary mounting hardware
 - 2. Acceptable manufacturers
 - a. Eritech (Erico)
 - b. Storm Copper Components
 - c. Or equal.
- G. Electrical joint inhibitor compound
- 1. Used for all bolted grounding connections as a moisture and oxidizing seal.
 - 2. Acceptable manufacturers:
 - a. Sanchem Inc., NO-OX-ID (A-Special Electrical Grade)
 - b. Or equal.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Prepare and clean piping, rods, and conductors prior to exothermic welding in conformance with the specific requirements of the welding system.
- B. Do not allow water pipe connections to be painted. If the connections are painted, disassemble them and provide new fittings.

3.2 INSTALLATION

A. General

- 1. Bond all steel building columns in new structures together and connect to the ground test station as shown on the drawings. Connections to structural steel columns shall be made with mechanical connectors.

2. Grounding of the pipe systems shall be provided per the requirements of CEC and as shown on the drawings.
3. Metal conduits stubbed into power distribution equipment, control panels, or other enclosure shall be terminated with insulated grounding bushings and bonded to the enclosure's ground bus. Size the bonding wire in accordance with the CEC, except that a minimum No. 12 AWG shall be used.
4. All equipment enclosures, motor and transformer frames, conduits systems, cable armor, cable tray, exposed structural steel and all other equipment and materials required by the CEC to be grounded, shall be grounded and bonded in accordance with the CEC.
5. For manholes/pull boxes with ground test stations, connect the ground test station to the site ground grid with two connections.
6. Care shall be taken to ensure good ground continuity, in particular between the conduit system and equipment frames and enclosures. Where necessary, jumper wires shall be installed.
7. In Classified Locations where equipment grounding conductor does not exist, liquid tight flexible metal and PVC coated liquid tight flexible metal conduits shall have an external equipment bonding jumper of the wire type and size in compliance with NEC 250.102. Bonding jumpers shall run parallel (not spiraled) and fastened with Type 316 stainless steel tie wraps.
8. Run grounding electrode conductors in the building concrete slab/wall or in slab/wall-embedded PVC Schedule 40 conduits unless otherwise shown on the drawings. Stub-ups at ground test stations and conduit runs underneath structures out to the perimeter ground ring shall be in PVC Schedule 80 conduit.
9. Ground cable penetrations through building exterior walls shall enter within 3 feet below finish grade and shall be prepared with a water stop. Unless otherwise indicated, the water stop shall include filling the space between stands with solder and soldering a 12-inch copper disc over the cable.
10. Install equipment grounding conductors with all feeders and branch circuits. Each circuit shall have a dedicated equipment grounding conductor from source to load without splicing or "tee tapping" (e.g., three different receptacle circuits in a common home-run conduit back to a lighting panelboard shall have three separate equipment grounding conductors back to the lighting panelboard).
11. All buried ground joints shall be exothermically welded.

C. Ground connections

1. Ground transformer neutrals, UPS neutrals, and other separately derived sources to the nearest GTS. Size the grounding electrode conductor in accordance with the CEC unless otherwise specified on the drawings.
2. Ground all grounding type receptacles to the outlet boxes with a No. 12 XHHW-2 green conductor connected to the ground terminal of the receptacle and fastened to the outlet box by means of a grounding screw.
3. Single-point ground instrumentation cable shields at the signal ground bus at the control panel end of the circuit.
4. Mechanically connect grounding electrode conductors to the foundation reinforcing steel where shown on the drawings.
5. Seal exposed connections between different metals with electrical joint inhibitor compound. Clean and coat all buried connections with electrical joint inhibitor compound before backfilling.
6. Do not bury or embed bolted connections. For compression-type connectors, the tool for crimping shall emboss the die index number into the connector as the crimp is completed. Each compression-type connector shall have an inspection port for use in checking proper conductor insertion.
7. Molds used for exothermic welding shall be new. The number of welds made per mold shall not exceed the manufacturer's recommendations.

D. Ground rods

1. Drive grounding electrodes at locations shown on the drawings. Provide a ground rod and GTS inside every medium voltage manhole and light pole hand hole.
2. Bury ground rods to the depth shown on the drawings. Interconnect ground rods with the wire size shown on the drawings.

E. Grounding wires

1. Unless otherwise specified, provide continuous, unspliced equipment grounding conductors.
2. Where grounding conductors extend beyond the perimeter of the building to site structures, the grounding electrode system shall be continuous and the grounding conductor shall be encased in concrete duct banks.

F. Fasteners

1. Clean the connector and conductor surfaces with a wire brush or emery cloth to a shiny, bright surface. For plated surfaces, use compatible solvent cleaning in order not to remove any portion of the plating.
2. Apply electrical joint inhibitor compound immediately after cleaning.
3. All fasteners shall engage a minimum of four full threads for electrical connections and equipment mounting.
4. Coat all bolts with electrical joint inhibitor compound.
5. Torque fasteners to NETA specifications.

G. Safety

1. Reference Section 01 35 44 Environmental Requirements prior to commencing work related to hazardous materials.

H. Wire identification

1. Tag and lace all wires in test stations, pull or junction boxes, vaults, at each termination. Wire identification text shall be as shown on the drawing. Reference Section 26 05 53 for identification products.

3.2 INSPECTION AND TESTING

- A. Inspect the grounding and bonding system conductors and connections for tightness, proper installation, and proper application of electrical joint inhibitor compound.
- B. Electrical continuity of the pipe system shall be tested.
- C. Notify the Engineer immediately if the resistance to ground for any building or system is greater than five ohms.

END OF SECTION

SECTION 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. This section covers the work necessary to furnish and install complete raceways and boxes for electrical systems.

B. Related sections:

1. Section 01 33 00 – Submittal Procedures
2. Section 01 43 11 – Seismic Requirements
3. Section 09 90 00 – Painting and Coating
4. Section 26 05 00 – Common Work Results for Electrical
5. Section 26 05 26 – Grounding and Bonding for Electrical Systems
6. Section 26 05 29 - Hanger and Supports for Electrical Systems
7. Section 26 05 53 – Identification for Electrical Systems
8. Section 26 08 00 – Commissioning of Electrical Systems

C. Related work specified elsewhere:

1. For trapeze and conduit supports using hangers, refer to Section 26 05 29 Hanger and Supports for Electrical Systems.

1.2 REFERENCES

A. California Code of Regulations

1. Title 24, Part 3 – California Electrical Code (CEC)

1.3 QUALITY ASSURANCE

A. Seismic design requirements for conduit hangers and supports:

1. All raceway systems to be furnished under this Section shall be designed and constructed to meet the seismic requirements of Section 01 43 11.

- B. The Contractor shall require that all persons engaged in the installation of PVC coated rigid galvanized steel conduit, elbows, nipples, and fittings attend installation training classes given by the approved manufacturer at the job site or factory before any conduit installation work begins. The classes shall be carried out by technically competent and experienced instructors who are certified manufacturer's employees and instructors acceptable to the Engineer. Installers must be able to show a valid, unexpired Installer Certification card.
- C. The Contractor shall demonstrate to the Engineer that the approved manufacturer's recommended installation tools and methods are being utilized on the job site by all persons engaged in the installation of PVC coated rigid steel conduit, elbows, nipples, and fittings. These tools and methods shall include, but not be limited to, clamp inserts for use on power driven units of chain vises, new die heads and enlarged pipe guides in conduit threading machines, and strap wrenches and extra wide wrench jaws for use in conduit assembly.

1.4 SUBMITTALS

- A. Make submittals in accordance with Section 01 33 00 Submittal Procedures, and Section 26 05 00 Common Work Results for Electrical.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Rigid Steel Conduit
 - 1. Hot-dipped galvanized rigid steel conduit, including threaded type couplings, elbows, nipples, and other fittings, shall meet the requirements of ANSI C80.1, ANSI C80.4, UL and the CEC. Do not use setscrew or threadless type couplings, bushings, elbows, nipples, and other fittings, except when approved in writing by the Engineer.
 - 2. Acceptable manufacturers:
 - a. Allied Tube and Conduit
 - b. Western Tube and Conduit
 - c. Or equal.
- B. PVC Schedule 40 and Schedule 80 Conduits
 - 1. PVC conduit shall be Schedule 40 or Schedule 80 as designated on the drawings, UL listed for concrete encased, underground direct burial, concealed and direct-sunlight-exposed use, and UL listed and marked for use with conductors having 90 degree C insulation. Conduits, couplings, elbows, nipples, and other fittings shall meet the requirements of NEMA TC 2 AND TC 3, Federal Specification W-C-1094, UL, CEC, and ASTM specified tests for the intended use. Use only conduit with a factory

formed bell on one end. Conduit that requires the use of couplings for straight runs will not be acceptable.

2. Acceptable manufacturers:
 - a. Carlon Plus 40 or Plus 80 Rigid PVC Nonmetallic Conduit
 - b. PW Pipe
 - c. Or equal.

C. PVC-coated rigid steel conduit

1. PVC-coated rigid steel conduit shall be hot-dipped galvanized rigid steel conduit meeting the requirements of NEMA RN 1, ETL PVC-001, UL 6, ANSI C80.1 and the CEC, and a factory installed PVC coating 40 mils nominal thickness, and applied over and permanently bonded to the galvanized surface, with an interior 2 mil urethane coating. All male threads on conduit, elbows, and nipples shall be hot galvanized and protected by an application of a urethane coating. Couplings, elbows, nipples and other fittings shall be threaded and galvanized and shall have integral plastic sleeves which overlap the plastic-coated conduit with pressure sealing sleeves. Use PVC coated conduit suitable for conductors with 75 degrees C insulation.
2. Acceptable manufacturers:
 - a. Robroy; Plasti-Bond RedH₂O_T
 - b. Perma-Cote
 - c. Or equal.

D. Flexible Metal Conduit, Liquid-Tight

1. Flexible metal conduit shall be UL listed, liquid-tight, consisting of galvanized steel flexible conduit covered with an extruded gray PVC jacket and terminated with nylon bushings or bushings with steel or malleable iron body and insulated throat and sealing O-ring.
2. Acceptable manufacturers:
 - a. Anaconda Sealtite Type UA
 - b. Electri-Flex Liguatite Type LA
 - c. Or equal.

- E. Pulling Tape – pulling conductors into conduits
1. Flat, woven, polyester tape used for installing fiber optic, copper, and coaxial cables in underground conduit. Tape shall have the following characteristics:
 - a. Lubricated for easy installation and reduced friction.
 - b. Printed with sequential footage markings.
 - c. 2,500 pound tensile strengths.
 2. Acceptable manufacturers:
 - a. NEPTCO, Polyester MULETAPE.
 - b. Or equal.
- F. Pulling Tape – Empty spare conduits
1. Flat, woven, polyester tape with insulated 22 gauge metallic conductor to enable detection of empty, spare conduits. Tape shall have the following characteristics:
 - a. Lubricated for easy installation and reduced friction.
 - b. Printed with sequential footage markings.
 - c. 2,500 pound tensile strengths.
 2. Acceptable manufacturers:
 - a. NEPTCO, Detectable MULETAPE, DT Series.
 - b. Or equal.
- G. Raceway Fittings
1. Fittings for Rigid Steel:
 - a. Watertight hubs for rigid steel conduit shall be male thread type zinc-plated malleable iron with recessed "O" ring seal, insulated throat, and locking screw.
 - 1) Acceptable manufacturers:
 - a) OZ Gedney, Type CHM-T
 - b) Cooper Crouse-Hinds, Raintight Malleable Iron "MHUB"

- c) Or equal.
 - b. Provide all malleable iron conduit bodies and covers with captive stainless steel screws and neoprene gaskets.
 - 1) Acceptable manufacturers:
 - a) Appleton, Form 35 Threaded Unilets
 - b) Killark, Duraloy 5 Series Malleable Iron
 - c) Or equal.
- 2. Fittings for Liquid-Tight Flexible Metal Conduit:
 - a. Straight, 45 degree angle, or 90 degree angle connectors with malleable iron gland nut, polyethylene compression ring, steel ferrule, malleable iron conduit assembly with insulated throat, steel lock nut, and copper grounding lug.
 - 1) Acceptable manufacturers:
 - a) Cooper Crouse-Hinds, Liquidator Series
 - b) Steel Electric Products
 - c) Or equal.
- 3. Fittings for PVC-Coated Rigid Steel Conduit:
 - a. Watertight and corrosion resistant hubs for PVC Coated Rigid Steel conduit shall have a minimum 40 mil PVC exterior coating, a urethane interior coating, and pressure sealing sleeves.
 - 1) Acceptable Manufacturers:
 - a) Robroy Plasti-Bond Red Type ST Hub
 - b) Perma-Cote Industries Supreme Type ST Hub
 - c) Or equal.

- b. For corrosion resistant conduit bodies for use with PVC Coated Rigid Steel conduit sized as required by the CEC, use cast iron conduit bodies and covers with captive stainless-steel screws, a 40 mil minimum PVC exterior coating and nominal 2 mil internal urethane coating, and pressure sealing sleeves on all conduit openings.
 - 1) Acceptable manufacturers:
 - a) Robroy Plasti-Bond Red Conduit Bodies
 - b) Perma-Cote Industries Supreme Conduit Bodies
 - c) Or equal.
- c. In NEMA 4X areas, provide zinc-plated malleable iron or galvanized steel insulated throat connectors for liquid-tight flexible metal conduit, suitable for use in wet locations, with a minimum of 40 mil PVC exterior coating and pressure sealing sleeves.
 - 1) Acceptable manufacturers:
 - a) Robroy Plasti-Bond Red Liquid Tight Connectors
 - b) Perma-Cote Industries Supreme Liquidtight Connectors
 - c) Or equal.

H. Expansion/Deflection Couplings

- 1. Provide expansion/deflection couplings for use where shown on the drawings and wherever conduit crosses an expansion joint. The couplings shall alleviate longitudinal, angular, and shear conduit stress caused by differential settlement.
- 2. Acceptable manufacturers:
 - a. Appleton/O-Z Gedney Type DX
 - b. Cooper/Crouse-Hinds Type XD
 - c. Or equal.

I. Conduit Sealing Fittings (EYS)

1. Provide EYS for use where shown on the drawings and in areas identified as hazardous location as defined in NEC 500.5. EYS is required on either or both sides of boundary entering or leaving hazardous area, including Class 1 Division 1, Class 1 Division 2, and non-classified areas. EYS are used in conduit runs to stop gasses, vapors or flames from migrating from one part of the conduit system to another. It also limits the spread of any potential explosion. All EYS shall have a minimum of five thread counts. The EYS shall be suitable for the application of the specific location and shall be rated for UL 1203, NEC, CEC, and CSA C22.2 No. 30. Installation shall meet the requirements in the NEC.
2. Acceptable manufacturers:
 - a. Plasti-Bond RedH₂O_T
 - b. Crouse Hinds
 - c. Or equal

J. Expansion Couplings

1. Provide expansion couplings for use where shown on the drawings. The couplings shall allow for expansion and contraction up to a maximum of 8" (4" in either direction) in a run of rigid metal conduit.
2. Acceptable Manufacturers:
 - a. Appleton/O-Z Gedney Type AX-8
 - b. Cooper/Crouse-Hinds Type XJG
 - c. Or equal.

K. Supports and Fittings

1. For non-NEMA 4X areas, supports and fittings for support systems for electrical equipment and raceways shall be channel supports sized to meet seismic requirements. Finish shall be hot-dipped galvanized steel for strut, pipe straps, clamp back spacers, hanger rod, strut nuts, U-bolts, beam clamps, and other supports and fittings.
 - a. Acceptable manufacturers:
 - 1) Unistrut, B-Line
 - 2) Power Strut
 - 3) Or equal.

2. For NEMA 4X areas; supports and fittings for support systems for electrical equipment and raceways shall be channel supports sized to meet seismic requirements. Materials of construction shall be 40 mil PVC coated hot-dipped stainless steel, or self-extinguishing fiberglass which meets UL-94V-0 flammability tests, for strut, pipe straps, clamp back spacers, hanger rod, strut nuts, U-bolts, beam clamps, and other supports and fittings.

- a. Acceptable Manufacturers:

- 1) Robroy Plastibond-Red PVC Coated Steel Strut and accessories
- 2) Perma-Cote Supreme PVC Coated Steel Channel and accessories
- 3) Or equal.

- L. Wireways

1. For NEMA 4X areas, provide UL listed, raintight, hinged cover NEMA 4X wireway bodies and covers fabricated from stainless steel.

- a. Acceptable Manufacturers:

- 1) Square D
- 2) Hoffman
- 3) Or equal.

- M. Boxes and Fittings

1. Type NEMA 1 terminal boxes, junction boxes, pull boxes etc. shall be sheet steel unless otherwise shown on the drawings. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 14 gauge metal. Boxes shall have continuous welded seams and shall be used for dry, nonprocess indoor locations shown on the drawings. Furnish terminal boxes with hinged doors, terminal mounting straps, and brackets. Terminal blocks shall be NEMA type not less than 30A, 600V.

- a. Acceptable Manufacturers:

- 1) Hammond Manufacturing
- 2) Weigmann
- 3) Or equal.

2. Type NEMA 12 terminal boxes, junction boxes, pull boxes, etc., shall be sheet steel unless otherwise shown on the drawings. Boxes shall have continuous welded seams and mounting feet. Welds shall be ground smooth. Boxes shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 14 gauge metal. Covers shall be gasketed with rolled lip and fastened with stainless steel clamps. Furnish boxes with continuous hinged doors, terminal mounting straps, and brackets. Terminal blocks shall be NEMA type, not less than 30A, 600V.
 - a. Acceptable Manufacturers:
 - 1) Hammond Manufacturing
 - 2) Weigmann
 - 3) Or equal.
3. Type NEMA 4X locations, terminal boxes, junction boxes, pull boxes etc., shall be Type 316L stainless steel (NEMA 4X locations) unless otherwise shown on the drawings. Boxes shall have continuous welded seams and mounting feet. Welds shall be ground smooth. Boxes shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 12 gauge metal. Covers shall be gasketed and fastened with stainless steel clamps. Furnish terminal boxes with hinged doors, terminal mounting straps and brackets. Terminal blocks shall be NEMA type, not less than 30A, 600V.
 - a. Acceptable Manufacturers:
 - 1) Hammond Manufacturing
 - 2) Weigmann
 - 3) Or equal.
4. All boxes and fittings used with PVC coated conduit shall be furnished with a PVC coating bonded to the metal, the same thickness as used on the coated steel conduit. The ends of couplings and fittings shall have a minimum of one pipe diameter PVC overlap to cover threads and provide a seal.
5. Device boxes shall be malleable iron with zinc electroplate and epoxy powder coat finish, malleable iron covers, and stainless steel screws. Provide the “deep” configuration for all device boxes.
 - a. Acceptable Manufacturers:
 - 1) Appleton, UNILETS Malleable Iron, Type FD

- 2) Steel Electric Products, Type FD
- 3) Or equal.

N. Conduit Penetration Seals and Sleeves

1. Conduit penetration seals shall be modular, mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the conduit and the opening. The elastomeric element shall be sized and selected per the manufacturer's recommendations and shall be suitable for use in standard service applications (-40 degree F to 250 degrees F).
2. Sleeves shall be the thermoplastic type with water stops, suitable for poured wall construction.
3. Conduit penetration seals and sleeves shall be complete assemblies supplied by a single manufacturer.
4. Acceptable manufacturers:
 - 1) Thunderline Corporation Link-Seal and Plastic Sleeves
 - 2) Calpico Inc. Pipe Linx and Plastic Sleeves
 - 3) Or equal.

O. Duct Seal for used with conduit in Non-Classified Areas and Non-Classified conduits and fittings.

1. Duct seal shall be a non-hardening compound designed as a waterstop and moisture barrier for sealing the annular space between conduit and electrical conductors and cables. Duct seal shall be adhered to conduit annular space and shall not adversely affect metal, PVC, polyethylene or rubber. Duct seal shall be paintable.
2. Acceptable manufacturers:
 - a. Ideal Industries Inc. , P/N 31-601
 - b. O-Z Gedney DUX
 - c. Thomas & Betts, Type DX
 - d. Or equal.

- P. Seal Compound for used with EYS and Hazardous Locations
1. In hazardous locations and applications where passage of gasses and vapors shall be minimized and to prevent the passage of flames through the conduit from one portion of the electrical installation to another, sealing compound shall be installed to comply with the NEC Article 501. Sealing compound shall be used in EYS and shall be UL listed. Sealing compound designed as a gas, waterstop, and moisture barrier for sealing the annular space between conduit and fitting and electrical conductors and cables.
 2. Acceptable manufacturers:
 - a. Chico A
 - b. Chico X
 - c. Chico SpeedSeal
 - d. Or equal.

PART 3 - EXECUTION

3.1 GENERAL

- A. Check the approximate locations of raceway system components shown on drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, consult the Engineer. Make modifications and changes required.
- B. Protection during construction:
 1. In addition to the requirements of Division 01, and Section 26 05 00, prior to installation, store all products in a dry location. Following installation, protect products from the effects of moisture, corrosion, and physical damage during construction. Keep openings in conduit and tubing capped with manufactured seals during construction. Cover PVC conduit, elbows, and PVC coated rigid steel conduit, nipples, elbows, and fittings from exposure to sunlight.

C. Material and equipment installation:

1. Follow manufacturer's installation instructions explicitly, unless otherwise indicated. Wherever any conflict arises between manufacturer's installation instructions, codes and regulations, and these contract documents, follow Engineer's decision. Keep copy of manufacturer's installation instructions on the jobsite available for review at all times.

3.2 NEMA AREA DESIGNATION

A. Boxes and conduit types are based on NEMA designation of locations described below.

1. NEMA 12: Interior, U16 Building, Guard Structure
2. NEMA 4X: Exterior, Blend Tank Area, Fog Area

3.3 INSTALLATION

A. Use no circular raceway less than 3/4-inch unless otherwise approved by the Engineer.

B. Raceway type for location and installation method unless noted otherwise on the drawings.

1. Exterior, Exposed (higher than 6-inches above grade), all locations except those designated as NEMA 4X:
 - a. PVC coated rigid steel conduit.
2. Interior, Exposed or Concealed (Not Embedded in Concrete), all locations except those designated as NEMA 4X:
 - a. Rigid steel conduit.
3. Embedded within Concrete Walls, Slabs, Ductbank or Floors:
 - a. PVC Schedule 40.
4. Risers from concealed nonmetallic conduit, floor stub-ups, wall, or ceiling penetrations; also, all locations designated NEMA 4X:
 - a. PVC coated rigid steel conduit.
5. Direct buried
 - a. PVC Coated Rigid Steel Conduit.

C. Location, Routing, and Grouping:

1. Conceal or expose raceways as indicated on the drawings. Group raceways in same area together. Locate raceways at least 12 inches away from parallel runs of heated piping for other utility systems.
2. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes to provide a neat appearance. Follow surface contours as much as possible.
3. Avoid obstruction of passageways. Run concealed raceways with the minimum of bends in the shortest practical distance considering the building construction and other systems.
4. In block walls, do not run raceways in the same horizontal course with reinforcing steel.
5. In outdoor, underground, or wet locations, use watertight couplings and connections in raceways. Install and equip boxes and fittings so as to prevent water from entering the raceway.
6. Paint all threads of galvanized conduits with zinc-rich paint or liquid galvanizing compound before assembling. Touch up after assembly to cover nicks or scars.
7. Do not notch or penetrate structural members for passage of raceways except with prior approval of the Engineer.
8. Do not run raceways horizontally in equipment foundation pads.
9. Separate raceway in slabs not less than three times the largest raceway outside diameter minimum, except at raceway crossings, and then only with the approval of the Engineer.
10. Do not run raceways across walkways.
11. Embed conduits in walls, floors, slabs, or overhead in the middle one-third of the concrete and at least 3-inches from the concrete surface; thicken slabs where necessary to accommodate conduits in a manner as approved by the Engineer.
12. Pull boxes, junction boxes, and/or handholes shall be used in any conduit run where a splice is required. Pull boxes shall be provided every 200 feet of straight run, every 150 feet with 90 degrees of bends, every 100 feet with 180 degrees of bends, and every 50 feet with 270 degrees of bends.
13. Conduits must be kept within the furring lines of building walls and ceilings unless specifically noted to be exposed.

14. Provide all necessary sleeves and chases required where conduits pass through floors or walls; seal all openings and finish to match adjacent surfaces.
15. Where conduit runs change from concrete embedded within floors, slabs, or equipment pads to exposed, maintain a minimum separation of 6-inches between the closest wall, pad, or structure face and the outer edge of the exposed conduit.

D. Special Locations:

1. In exterior light pole foundations; extend PVC schedule 40 conduit 6 inches above the top of the foundation.
2. Where conduit changes from underground direct burial to exposed, extend PVC coated rigid steel conduit minimum 6-inches above finished grade.
3. Where conduit changes from concrete embedded within walls, slabs, and floors to exposed, embed PVC coated rigid steel conduit and factory manufactured elbows from the concrete to exposed, and extend PVC coated rigid steel conduit a minimum of 6-inches beyond the concrete walls, slabs, or floors.
4. Under equipment mounting pads (direct burial), use PVC coated rigid steel conduit.
5. Final Connection to Equipment:
 - a. In area's not classified as Class 1, Division 1 or Division 2 make final connection to motors, wall or ceiling mounted fans and unit heaters, dry type transformers, valves, local instrumentation, and other equipment where flexible connection is required to facilitate removal or adjustment of equipment with 18-inch minimum, 60-inch maximum lengths unless otherwise approved by the Engineer, of liquid-tight, PVC-jacketed flexible metal conduit where the required conduit size is 4 inches or less. For larger sizes, use rigid steel conduit as specified.
 - b. The flexible conduit shall be long enough to allow the item to which is connected to be withdrawn or moved off its base. Use liquid-tight flexible metal conduit in outside areas, process areas exposed to moisture, and areas required to be oil-tight and dust-tight.

6. Conduit Sealing Fittings (EYS):

a. Conduits passing:

- 1) Between Class 1, Division 1 and Class 1, Division 2 areas; Class 1, Division 1 and non-classified areas; Class 1, Division 2 and non-classified areas; provide EYS located at the boundary in accordance with NEC Article-500.
- 2) From hazardous area into a non-hazardous area.

b. Install the seal compound material in the conduit sealing fittings after inspection.

E. Support:

1. Support raceways at intervals not exceeding CEC requirements unless otherwise indicated. Support multiple raceways adjacent to each other by ceiling trapeze. Support individual raceways by wall brackets, strap hangers, or ceiling trapeze, fastened by toggle bolts on hollow masonry units, expansion shields on concrete or brick, and machine screws or welded thread studs on steelwork.
2. Threaded studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of expansion shields.
3. Support all raceways from structural members only. Do not support from pipe hangers or rods, cable tray, or other conduit.
4. Do not use nails anywhere or wooden plugs inserted in concrete or masonry as a base for raceway or box fastenings. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.
5. Support flexible conduit with conduit clamps, except where the flexible conduit is fished and where sections less than 4 feet in length are used in concealed areas to supply lighting fixtures in accordance with the CEC.

F. Bends:

1. Make changes in direction of runs with symmetrical bends or cast metal fittings. Make bends and offsets of the longest practical radius. Avoid fieldmade bends and offsets where possible, but where necessary, make with an acceptable hickey or conduit bending machine. Do not heat metal raceways to facilitate bending.
2. Make bends in parallel or banked runs of raceways from the same center or centerline so that bends are parallel and of neat appearance. Factory elbows may be used in parallel or banked raceways if there is a change in the plane of the run and the raceways are of the same size. Otherwise, make field bends in parallel runs.

3. For PVC Schedule 40 conduits, use factory made elbows for all bends 30 degrees or larger. Use acceptable heating methods for forming smaller bends.
4. Make no bends in flexible conduit that exceed allowable bending radius of the cable to be installed or that significantly restricts the conduits flexibility.

G. Threaded Joints:

1. Paint all fieldcut threads with zinc rich paint or liquid galvanizing compound for rigid steel conduit after removal of chips and cleaning with solvent and use manufacturer approved thread compound for PVC coated rigid steel conduit. Use approved, highly conductive jointing compound on all joints
 - a. Approved Manufacturers:
 1. Appleton Type TLC
 2. Or equal.

H. Bushing and Insulating Sleeves:

1. Where rigid steel conduit, PVC coated rigid steel conduit, or liquid-tight flexible metal conduit enters metal enclosures, install an insulated throat grounding bushing on the end of each conduit. Install a bonding jumper from the bushing to any equipment ground bus or ground pad. Interconnection of bonding jumpers from each conduit grounding bushing to the equipment ground bus or ground pad is acceptable.
2. If neither a ground bus or ground pad exists, connect the bonding jumper to the metallic enclosure with a bolted-lug connection.
3. Make conduit connections to NEMA 3R, NEMA 4, or NEMA 4X enclosures, junction boxes, terminal junction boxes, or device outlet boxes with watertight, corrosion resistant hubs. The conduit connections shall maintain the integrity of the enclosure NEMA rating.

I. Expansion Joints:

1. Provide expansion/deflection fittings for raceways crossing expansion joints in structures, between structures and walkways, bridges, or concrete slabs to compensate for expansion, contraction, and deflection. Provide expansion only fittings in every 200 feet of exposed, straight, rigid steel conduit runs.

J. PVC Coated Rigid Steel Conduit:

1. Install in strict accordance with the manufacturer's instructions. Touch up any damage to the coating with conduit manufacturer touch-up compound. PVC boot shall cover all threads. Where belled conduits are used, bevel the unbelled end of the joint before joining. Leave no metallic threads uncovered. Clean field threads with solvent and coat with urethane touch-up. Keep two cans of urethane touch-up at each threading station.

K. Penetrations:

1. Seal the interior of all raceways entering structures or buildings at the first box or outlet with duct seal to prevent the entrance into or exit from the structure of gases, liquids, or rodents.
2. Where conduit enters a new structure above ground or below grade through a concrete roof or wall, install a watertight conduit penetration seal and sleeve. Install the sealing assembly such that it may be tightened at any time from the interior side. For wall and roof penetrations, dry pack with non-shrink grout around the conduit and the sealing assembly on the exterior side. Where conduit enters a new structure below grade through a concrete floor, cast the conduit directly into the concrete floor slab.
3. Where conduit enters an existing structure above ground or below grade through a concrete roof or wall, core drill through the existing roof or wall and install a watertight conduit penetration seal. Install the sealing assembly such that it may be tightened at any time from the interior side. Dry pack with non-shrink grout around the conduit and the sealing assembly on the exterior side.
4. Where raceways penetrate fire rated walls, floors, or ceilings, provide fire stop material per Section 07 84 00 in openings around electrical penetrations to maintain the fire resistance rating.
5. All NEMA 4X enclosures without integral watertight hubs shall have watertight, threaded, rigid, conduit hubs.
6. Perform non-destructive scanning on all walls, floor, and ceiling penetrations prior to core drill.

L. Wireways

1. Mount wireways securely in accordance with the CEC and manufacturer's instructions. Locate removable cover on accessible vertical face of wireway unless otherwise indicated.

M. Preparation for Pulling in Conductors

1. Do not install crushed or deformed raceways. Avoid traps in raceways. Take care to prevent the lodging of plaster, concrete, dirt, or trash in raceways, boxes, fittings, and equipment during the course of construction. Make raceways entirely free of obstructions or replace them. Ream all raceways, remove burrs, and clean raceway interior before introducing conductors or pull tape.
2. For existing underground concrete-encased and direct-buried raceways, prove the integrity of the raceway system as specified in Section 26 05 43 before pulling in conductors.
3. Immediately after installation, plug or cap all raceway ends with watertight and dust-tight seals until the time for pulling in conductors.

N. Empty Raceways

1. Certain raceways will have no conductors pulled in as part of this Contract. Identify with conduit tags at each end and at any intermediate pull point of each such empty raceway. Provide a removable cap over each end of empty raceways. Provide a detectable pull tape with a minimum of 3-feet of slack at each end in each empty raceway. Provide cap with eyelet for attaching the pull tape.
2. Strip insulation from the jacket of the detectable pull tape wire and attach to the ground rod in each manhole or pullbox, to the frame of metallic pullboxes, to switchgear ground busses, to switchboard ground busses, and to control panel ground busses.

3.4 PAINTING

- A. Paint exposed metal raceway systems in finished areas in accordance with the requirements in Section 09 90 00.

END OF SECTION

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:

1. All electrical equipment and systems shall include identification tags or nameplates as shown on the drawings and as specified herein.
2. The Contractor shall develop a tagging system in accordance with the conduit and cable schedules and submit same to the Engineer for review and approval before proceeding.

B. Related Sections:

1. Section 01 33 00 – Submittal Procedures
2. Section 26 05 00 – Common Work Results for Electrical
3. Section 26 08 00 – Commissioning of Electrical Systems

1.2 SUBMITTALS

A. Submittals shall be made in accordance with Section 01 33 00

B. In addition to the requirements of Section 01 33 00:

1. Submit proposed identification system products including catalog data sheets and literature applicable to the requirements of this Section.
2. A tagging system scheme or schedule shall be submitted to the Engineer for review and approval prior to tagging of equipment.

PART 2 - PRODUCTS

2.1 PRODUCTS

A. Conduit Identification Tags

1. Provide permanent, stamped SS316 round tags conduit numbers as designated on the conduit schedule drawings, pressure stamped onto the tag. Tags relying on adhesives or taped-on markers are not acceptable. Attach tags to conduits with 316 stainless steel wire at each end. Attach tags to conduits at least once in every 50 feet near the midpoint of exposed conduit in ceiling spaces, on surface mounted conduit, and on conduit inside manholes and handholes.

B. Cable Identification Tags

1. Wire tags relying on adhesives or taped-on markers are not acceptable.
2. Provide white heat-shrinkable polyolefin sleeve wire tags with legible machine printed weatherproof black marking. Wire tag shall be glossy finish, minimum 0.020-inch wall thickness, and 2 inch width minimum.
3. Wire tag diameters shall be appropriate for the required lines of text and/or wire size. Wire tag diameters used shall be consistent amongst wires of similar signal types.
4. Performance temperature -40°F to 212°F, humidity resistance 95% R.H. and UV resistance.
5. Meet UL Standard 224 for flammability.
6. Provide necessary tools and accessories to print labels and shrink labels.
7. Acceptable Manufacturers:
 - a. Brady, B33 Series B-342 PermaSleeve Marker, Model B33-125-2-342, B33-250-2-342.
 - b. Panduit, Permanent Sleeve, Model H200X025H1T, H200X044H1T.
 - c. Or equal.

C. Equipment Nameplates

1. The legend plates or nameplates shall be a minimum of 1/2” inches high and 2 – 1/2 inches wide and shall be attached to the equipment by means of round head stainless steel machine screws. The plates shall be approximately 3/22-inch thick with beveled edges and shall have letter sizes and legends as accepted by the Engineer.
2. Plates shall be made of laminated phenolic material with a black surface layer and white base material beneath. Engraved letters shall be 1/4-inch high extending through the black face into the white layer resulting in white letters on black background.
3. Where nameplates cannot be mounted on the equipment, attach the nameplate or tag with a stainless-steel cable.
4. Acceptable Manufacturers:
 - a. Brady
 - b. Seton

c. Or equal.

D. Pushbutton Legend Plates

1. Provide legend plates for pushbuttons, selector switches, pilot lights, and process displays with inscription as shown on the drawings. Provide adapter ring as necessary to fit devices with legend plates. Legend plates shall be made by same manufacturer as pushbutton device, selector switch and pilot light.
2. Acceptable Manufacturers:
 - a. Cutler-Hammer HT800 Series
 - b. Allen Bradley Bulletin 800T
 - c. Or equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Conductor Identification:

1. Identification system shall use the format shown on Conduit Schedule Drawings.
2. Identify conductors at each termination and in all accessible locations such as manholes, handholes, control panels, panelboards, pull boxes, junction boxes, wireways, junction terminal boxes, switchgear, motor starters, disconnect switches, etc. For identification, use type of conductor and cable tags specified herein.

B. Nameplates

1. Nameplates shall be permanently attached to the device specified and located on the device so as to be easily read under normal operation of the device. Nameplates shall not alter nor limit the rating, function, UL listing, and enclosure NEMA rating of the device. Nameplates shall be smoothly attached to the device with no overlaps, protrusions, or sharp edges and corners.
2. Nameplates shall be installed on the doors or covers of all panels, panelboards, starters, contactors, relays and all other electrical equipment enclosures furnished under this Contract and as indicated on the drawings.
3. Nameplates shall be engraved with inscriptions as shown on the drawings; if not shown, Contractor shall submit a schedule showing what is shown as well as what is proposed for the Engineer's approval.

4. Each device which indicates the operation of the equipment, or which may be operated to affect the equipment, shall have an integral legend plate or nameplate indicating the device function. These shall be inscribed as indicated on the drawings or as approved by the Engineer.

C. Conduit numbers

1. Label conduits with conduit numbers as shown on drawings.

D. Cable numbers

1. Label cables with cable numbers as shown on drawings.
2. Install a cable numbers at maximum 100-foot intervals.

E. Raceways

1. Contractor shall assign conduit and cable numbers in accordance with the following system where raceway numbers have not been assigned

| Raceway Prefix | Type of Function |
|----------------|--|
| C | Control or power - 120V or less |
| N | Pneumatic tubing |
| P | Power 120V to 600V |
| S | Signal - data communication or instrumentation |

Prefixes shall be followed by a 3-to-4-digit number. Add a letter suffix to distinguish the raceway to designate a sub-branch from the main raceway.

Example:

Raceway number = P109A where:

P = conduit contains power

109 = unique 3-digit number

A = letter to distinguish raceway feed off from the raceway #109

3.2 TAGGING OF WIRES AND CABLES

- A. All wires and cables shall be neatly bundled, tagged, and laced in pull or junction boxes, manholes, handholes, wireways, and at each termination. Each bundle of wire and cable shall be tagged at least once as it passes through each pull or junction box, manhole, handhole, and at each termination. Each bundled wire and cable shall be tagged at least once as it passes through wireways. Wires and cables shall be laced into groups representing each individual circuit, and each group or cable shall be tagged with the corresponding circuit number or cable number. Power, lighting, control, alarm, annunciator, and instrumentation wiring shall be bundled, laced, and tagged, as specified herein.

- B. Tags for use in pullboxes, handholes, and manholes shall be made of minimum 1/8- inch-thick black laminated plastic, 1-1/2-inch by 3-1/2-inches, with white engraved identification in letters 3/64-inch deep by 3/16-inch high minimum. Tags shall be drilled at each end and secured twice to each cable or laced-together with plastic tie wire or other method approved by the Engineer.
- C. All wires and cables within control panels, switchgear, motor control centers, mechanical mounting panels, terminal junction boxes, etc., shall be tagged at each termination with conductor tags as specified. All circuit identification tags shall be readily accessible for inspection at the locations cited above.
- D. Label wires with cable numbers as shown on the drawings. Cable labels shall be placed within one inch of the ends of the cable jacket.
- E. All spare pairs shall be bundled and labeled with the cable designation. All individual pairs shall be tagged to enable identification of spare pairs when making future terminations.
- F. Identify multi-circuit control cables and individual instrumentation and control circuits as indicated on the Drawings. Multi-circuit cable shall be tagged with the cable name around the entire cable assembly and shall have the individual circuits tagged as well. Tag twisted, shielded pairs and where exposed, multi-pair cable twisted pairs around each pair separately.
- G. Identify each individual conductor at each termination. This includes such locations as switchgear, switchboards, motor control centers, variable frequency drives, control panels, junction/terminal boxes, all field devices, security panels and junction boxes, and all other locations where conductors are terminated. Identify the termination of these conductors in accordance with the accepted shop drawings. Tag conductors with sleeve type labels.
- H. Where more than 1 nominal voltage system exists, identify each ungrounded system conductor by phase and system. Permanently post means of identification at each branch-circuit panelboard, switchboard, switchgear, motor control center, or other type of power distribution equipment.
- I. Include the following minimum information for wire and cable identification:
 - 1. Circuit number or load identification tag number.
 - 2. Origin (from source)
 - 3. Destination (to load)

J. Wire Numbers:

1. The Contractor shall coordinate the wire numbering system with all vendors of equipment so that each and every field wire has a unique wire number associated with it for the entire system.
 - a. Wire numbers shall correspond to the wire numbers on the control drawings, or panel and circuit numbers for receptacles and lighting.
 - b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
 - c. Internal panel wires on a common terminal shall have the same wire number assigned.
 - d. Wire and cable identification on each conductor or cable shall be limited to two lines of text.
 - e. Multi-conductor cable shall be assigned a number which shall be attached to the cable at intermediate pull boxes and at stub-up locations beneath free-standing equipment. All individual control conductors and instrumentation cable shall be identified at pull points as described above.
 - 1) Armored multi-conductor cable shall be labeled using the conduit number shown on the plans, following the requirements for conduit markers as specified herein.
2. The following wiring numbering scheme shall be followed throughout the project and used for field wire numbers between control panels (including control stations, local control panels, process control systems, and vendor control panels), MCCs, field instruments, etc.

(ORIGIN LOC.) – (ORIGIN TERM.) / (DEST. LOC.) – (DEST. TERM.)

OR

(ORIGIN LOC.) – (ORIGIN TERM.)
(DEST. LOC.) – (DEST. TERM.)

Where:

ORIGIN LOC. = Originating panel or device location.

ORIGIN TERM. = Originating terminal at originating panel or device.

DEST. LOC. = Designation for destination panel or device.

DEST. TERM. = Terminal designation at destination panel or device, OR

DEST. TERM. = PLC I/O address at destination panel.

- a. Equipment and field instruments are always identified as the origin.
- b. Control panels are always identified as the destination.
- c. Example: W94-1WFSH01-C / W94EELCP01-TB1-5
 - 1) The origin is an eyewash flow switch.
 - a) Instrument Tag: W94-1W-FSH-01
 - b) Facility area code: W94 (De-Chlorination Facility)
 - c) Process / System Type: 1W (No. 1 Water)
 - d) Instrument Type: FSH (Flow Switch High)
 - e) Loop No.: 01
 - f) Terminal No.: C (Common)
 - 2) The destination is a local control panel.
 - a) Panel Tag: W94-EE-LCP-01
 - b) Facility area code: W94 (De-Chlorination Facility)
 - c) Process / System Type: EE (Electrical Equipment)
 - d) Control Panel Type: LCP (Local Control Panel)
 - e) Loop No.: 01
 - f) Terminal Block No.: TB1
 - g) Terminal No.: 5
- d. The following are examples of abbreviations used in the tagging process:
 - 1) VCP – Vendor Control Panel
 - 2) PCSP – Process Control System Panel
 - 3) LCP – Local Control Panel
 - 4) MCC – Motor Control Center
 - 5) SWB – Switchboard
 - 6) SWR - Switchgear

7) See the standard drawings for additional process and equipment abbreviations.

- e. Location designation is the facility area code, equipment tag, and loop number with hyphens omitted.
- f. Terminal designation in control panels is the terminal block number (terminal grouping number) followed by a hyphen and the actual number on the terminal where the conductor terminates. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.

Example: W94EELCP01-TB2-3

- g. Terminal designation in MCCs is the starter cell or bucket number followed by a hyphen and the terminal number.

Example: W94EEMCCP37-2D-12

- h. Terminal designation in field instruments or vendor panels is the terminal block number (terminal grouping number) followed by a hyphen and terminal number or symbol. The terminal designation is a terminal number or symbol, only, in the absence of terminal blocks or groupings.

Example: W94SBSFIT01-+

- i. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (T1, T2, T3, etc.)

Example: W94DFEPMP01-T1

- j. Terminal designations at control panels where the field conductor connects directly to a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project).

W:X:Y/Z for a discrete point or W:X:Y.Z for an analog point.

W = I for input, O for Output.
X = PLC number (1,2,3...).
Y = Slot number (01, 02, 03...).
Z = Terminal number (00, 01, 02...) for a discrete point or Word Number (1,2,3...) for an analog point.

Examples of discrete points: I:1:01/01, O:2:10/07

Examples of analog points: I:1:01.2, O:2:02.3

k. Terminal designations at control panels where the conductor does not connect to a PLC I/O point shall be the terminal number with a “C” prefix (C0010). For common power after a fuse or neutrals after a switch the subsequent points will have an A, B, C, ... etc. suffix (C0010A).

3. Case 1: Vendor Control Panel (VCP) to Process Control System Panel (PCSP):

Field wire number/label: A-B/C-D

- A = Vendor Control Panel number without hyphen (VCP111).
- B = Terminal number within VCP, MCC, or starter (manufacturer/vendor’s standard with be acceptable).
- C = Process control system panel without a hyphen (PCSP100).
- D = Either PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010).

Examples: VCP111-10/PCSP100-I:1:01/01.
VCP111-10/PCSP100-O:1:10/07.
VCP111-10/PCSP100-C0100.

4. Case 2: Field instrument to PCSP:

Field wire number/label: C-D/E-F

- C = Process control module without hyphen (PCSP100).
- D = Either PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010).
- E = Field mounted instrument tag and loop numbers without hyphen (PIT300).
- F = Manufacturer’s standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma.

Examples: PIT300-2,3/PCSP300-I:1:01.1.
TSH101-1/PCSP200-I:2:01/00.

5. Case 3: Motor Control Center (MCC) to PCSP:

Field wire number/label: B-C/D-G

- B = Terminal number within VCP, MCC, or starter (manufacturer/vendor’s standard will be acceptable).
- C = Process control module without hyphen (PCSP100).
- D = Either PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010).
- G = MCC use actual starter designation in MCC i.e., MS131 without hyphen located in MCC-120.

Examples: MS131-10/PCSP100-I:1:01/01.
MS131-10/PCSP100-O:1:10/07.
MS131-10/PCSP100-C0100.

6. Case 4: MCC to VCP:

Field wire number/label: A-B/G

- A = Vendor Control Panel number without hyphen (VCP111).
- B = Terminal number within VCP, MCC, or starter (manufacturer/vendor's standard will be acceptable).
- G = MCC use actual starter designation in MCC i.e., MS131 without hyphen located in MCC-120.

Example: MS131-X2/VCP111-10.

7. Case 5: Motor leads to MCC

Field wire number/label: B-G/H-I

- B = Terminal number within VCP, MCC, or starter (manufacturer/vendor's standard will be acceptable).
- G = MCC use actual starter designation in MCC i.e., MS131 without hyphen located in MCC-120.
- H = Equipment tag and loop number without hyphen (RWP131).
- I = Motor manufacturer's standard motor lead identification (T1, T2, T3, etc.)

Example: RWP131-T1/MS131-T1.

8. Case 6: Remote or separately mounted starters or VFDs to PCSP:

Field wire number/label: B-C/D-J

- B = Terminal number within VCP, MCC, or starter (manufacturer/vendor's standard will be acceptable).
- C = Process control module without hyphen (PCSP100).
- D = Either PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010).
- J = Remote mounted starter or VFD tag and loop number without hyphen (MS121)

Examples: MS121-10/PCSP100-I:1:01/01.
MS121-10/PCSP100-O:2:10/07.
MS121-10/PCSP100-C0010.

9. All spare conductors shall be terminated on terminal blocks and shall be identified as required for other field wires, with an "S" prefix.

Example: SMS315-21/PCM200-C0125

3.3 SWITCHGEAR CONTROLS IDENTIFICATION

- A. Provide nameplates for switchgear controls located at switchboards as shown on the elevation drawings.

END OF SECTION

SECTION 26 05 83

LOW VOLTAGE MOTORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:

1. AC Motors, up to 500 horsepower, furnished under other Sections of these Specifications, shall be in conformance with the requirements listed in this Section unless otherwise noted.

B. Related sections:

1. Section 26 05 00 - Common Work Results for Electrical
2. Section 26 05 19 - Low Voltage Power Conductors and Cables
3. Section 26 08 00 - Commissioning of Electrical Systems
4. Section 26 29 23 – Low-Voltage Variable-Frequency Motor Controllers (Re-use existing, no new variable frequency motor controllers to be provided)

1.2 REFERENCES

A. Acoustical Society of America (ASA)

1. ANSI/ASA S12.51, Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for reverberation test rooms.

B. American Petroleum Institute (API)

1. ANSI/API Standard 610, Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries.

C. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 43 - IEEE Recommended Practice for Testing Insulation Resistance of Electric Machinery.
2. IEEE 841, "IEEE Standard for Petroleum and Chemical Industry – Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors – Up To and Including 370 KW (500 HP)."
3. IEEE 112, "Standard Test Procedure for Polyphase Induction Motors and Generators."

4. IEEE 114, "Standard Test Procedures for Single-Phase Induction Motors."
- D. National Electrical Contractors Association (NECA)
 1. ANSI/NECA 230 - Standard for Section, Installing, and Maintaining Electric Motors and Motor Controllers.
- E. National Electrical Manufacturers Association (NEMA):
 1. NEMA MG1, "Motors and Generators"
- F. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.3 SUBMITTALS

- A. Submittals shall be made in accordance with Section 01 33 00.
- B. Submittal of motor data for acceptance shall include complete nameplate data and, in addition, the following for motors typical of the units furnished:
 1. Clearly mark on submittals that the motors being supplied meet or exceed the requirements of IEEE 841.
 2. For vertical motors where not all IEEE Std 841 features can be applied, motors shall be designed and labeled as "Meet the Intent" of IEEE-841.
 3. Motor outline, mounting details, dimensions, and weight including location and size of conduit boxes
 4. Descriptive bulletins, including:
 - a. Rated horsepower, voltage, full load current, kVA code, and locked rotor current at rated voltage.
 - b. Frequency and number of phases
 - c. Motor connection diagram.
 - d. Service factor, design duty, insulation class, and temperature rise by resistance.
 - e. Ambient temperature and altitude ratings
 - f. NEMA design class.
 - g. Nominal and full load speed
 5. Motor performance data sheet.

6. Manufacturer's installation and maintenance manual showing details relating to shipment, handling, storage, foundation requirements, initial installation, normal operation, doweling, disassembly, reassembly, lubrication, recommended renewal parts and procedure to obtain service, relevant cutaway drawings, and troubleshooting matrix.
 7. Manufacturer's recommended renewal parts list. Include both the bearing manufacturer's and motor manufacturer's part number for the ODE and DE bearings, along with the current list price for each bearing.
 8. Diagrams, including motor lead wiring connection, space heater connection, and temperature detector connection.
 9. Bearing and lubrication system design data.
 10. Special features (e.g., space heaters, temperature detectors, etc.).
 11. Enclosure type and finish
 12. Certified factory test reports as specified herein and in accordance with NEMA Standards MG1-Part 12. Submit test results for actual motors provided where so specified.
 13. Motor Data Sheet for each three-phase motor. A sample motor data sheet is provided in Appendix A of the specifications.
- C. Provide the following "typical" prototype performance test data for each motor specified:
1. Speed-torque and speed-current curves at 80% and 100% nominal line voltage, from zero speed to synchronous speed.
 2. Bearing and winding temperature rise tests at rated horsepower.
 3. Amperes at SF, 100%, 75%, 50%, and 25% of full load; no-load amperes; and locked rotor amperes
 4. Efficiency at SF, 100%, 75%, 50%, and 25% of full load
 5. Power factor at SF, 100%, 75%, 50%, and 25% of full load
 6. Airborne sound power in dBA
 7. Slip and full-load rpm
- D. Provide the following additional "typical" test reports:
1. Reed critical frequency data
 2. Bearing life calculation

3. Acceleration time vs. amperes curve
 - a. The driven equipment supplier shall provide the load WK^2 and load speed vs torque curve to the motor supplier in order to construct this curve. Provide curves at 80% and 100% nominal line voltage.
4. Equivalent circuit parameters (slip, I_1 , I_2 , R_1 , X_1 , R_2/s , X_2 , and X_m at both full-load and locked rotor). Include the following additional data:
 - a. Total R, X, Z, and X/R ratio
 - b. AC time constant
 - c. DC time constant
 - d. Open circuit time constant
 - e. Sub transient reactance
 - f. R_{1T} @ 25 deg C
5. Safe stall time (hot) / thermal limit curve, logarithmic inverse time vs. percent full load current curve.
6. Lateral critical speed analysis data
 - a. Rotor data
 - 1) Rotor core location, rotor core length, ODE bearing and DE bearing location data.
 - 2) Rotor core diameter, shaft end-to-end length, rotor core weight, and rotor assembly weight.
 - 3) Rotor polar and transverse moment of inertia and shaft/rotor ASM balance grade.
 - b. Bearing data
 - 1) ODE bearing number and stiffness
 - 2) DE bearing number and stiffness
 - c. Shaft data
 - 1) Shaft drawing, material, density, and yield
 - 2) Shaft tensile strength, Young's modulus, and shear modulus

7. Torsional analysis data
 - a. Shaft torsional stiffness
 - b. Effective diameter of shaft extension with keyway
- E. Factory Testing
 1. All factory testing will be unwitnessed.
 2. Provide the following factory test reports for the actual motor provided (i.e., not typical or calculated data)
 - a. IEEE 841 tests
 - 1) Winding resistance at 25 deg C
 - 2) No-load current, watts, frequency, and speed at rated voltage and frequency.
 - 3) Locked rotor voltage, current, and frequency
 - 4) Bearing inspection pass/fail
 - 5) Vibration test pass/fail
 - 6) High-potential test
 - 7) Unfiltered vibration velocity in inches/second at no-load, with two readings perpendicular to each other in the radial plane at the DE and ODE bearings as follows (12 total unfiltered radial plane vibration readings):
 - a) Overall
 - b) 2x RPM
 - c) 2x line frequency
 - 8) Unfiltered axial vibration velocity at the ODE bearing.
 - b. Complete test meeting IEEE Standard 112, Method B
 - 1) Full-load heat run, including temperature rise and winding resistance.
 - 2) Slip, no-load current, locked rotor current and torque, breakdown torque (calculated), and efficiency and power factor at 100%, 75%, and 50% full load.

- 3) Insulation resistance per IEEE Standard 43
 - 4) Winding resistance at 25 deg C
 - c. Sound test performed at no-load per ANSI S12.51 and NEMA MG-1.
 - d. Reed critical frequency (RCF) test
 - e. API-610 flange mounting tolerances
 - 1) Shaft, face, and register runout (TIR) and end play.
 - 2) Shaft extension diameter measurements at minimum five equally spaced intervals
 - f. If the driven equipment specifications require using the actual job motors for the pump factory performance test, the unwitnessed factory test reports shall be submitted approved by the District prior to shipment of the motors.
- F. IEEE-841 Data Sheet with all data fields completed by the motor and driven equipment vendors.

1.4 QUALITY ASSURANCE

- A. Single speed, totally-enclosed fan cooled, squirrel-cage polyphase induction motors shall be designed and manufactured in accordance with the latest version of IEEE Standard 841.
- B. Unless noted otherwise herein, routine tests shall be performed on representative motors in accordance with IEEE Standard 112, and shall include the information described on NEMA MG1-Part 12. Efficiency shall be determined in accordance with IEEE Publication No. 112, Method B. Power factor shall be measured on representative motors.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Delivery, Handling, and Unloading
 1. Handle the motor in accordance with the manufacturer's installation, operation, and maintenance manual. Equipment needed to handle motors in the frame size of this specification typically includes a hoist and spreader bar arrangement of sufficient strength to lift the motor safely using the lifting lugs or eyebolts on the machine.
 2. For motors with oil lubricated bearings, do not move motors with oil sumps filled.

B. Acceptance at Site

1. Upon receipt of the motor, carefully inspect the unit for any signs of damage that may have occurred during shipment.

C. Storage and Protection

1. Store motors indoors in a clean, dry location with space heaters energized to preclude moisture buildup. Connect heaters upon delivery of the motor.
2. Cover the motors with a canvas tarpaulin. Do not wrap the motor in plastic. The cover shall extend to the ground and fit loosely over the motor to allow the captive air space to breath, minimizing the formation of condensation.
3. Coat all machined surfaces, including the shaft extension, with rust preventative material, Rust Veto No. 342 by E.F. Houghton, Co., or equal. Check the coating every month and re-coat as necessary.
4. Rotate the shaft once a month to maintain lubricant film on the bearing races and journals.
5. Bearings:
 - a. Grease
 - 1) Completely fill grease lubricated cavities with the lubricant specified in the manufacturer's installation, operation, and maintenance manual. Remove the drain plug and fill cavity with grease until grease begins to purge from the drain opening.
 - 2) Inspect grease monthly for moisture and oxidation by purging a small quantity of grease through the drain. If any contamination is present, completely remove and replace the grease.
 - b. Oil
 - 1) Oil lubricated motors are shipped without oil. Upon delivery of the motor, fill the oil sumps to the maximum capacity indicated on the oil chamber sight gauge window with the oil specified in the manufacturer's installation, operation, and maintenance manual.
 - 2) Do not move the motor with oil in the reservoir. Drain oil before moving to prevent sloshing.

- 3) Apply new thread sealant, Gasoila No. SS08 or equal, to the threads of the drain plug and inside the drain hole each time oil is drained and refilled.
- 4) Inspect oil monthly for evidence of moisture or oxidation. Replace the oil whenever contamination is evident or every twelve months in storage or non-operation, whichever occurs first.

6. Insulation resistance testing

- a. Disconnect all external accessories that have leads connected to the winding and connect them to a common ground. Connect all other accessories that are in contact with the winding to a common ground.
- b. Perform a one minute insulation resistance test on the winding using 500 VDC for one minute. Correct the reading to 40 deg C. The minimum acceptable insulation resistance is 5 megohms.
- c. Perform a polarization index (PI) test by taking the ratio of a 10 minute reading to the one minute reading. The minimum acceptable PI is 2.0. If the one minute insulation resistance reading corrected to 40 deg C is above 5,000 megohms, disregard the PI reading.

1.6 COMMISSIONING

- A. Commission the equipment as specified in Section 01 75 17 and Section 26 08 00.

PART 2 - PRODUCTS

2.1 RATING

- A. Each motor shall develop ample torque for its required service throughout its acceleration range at a voltage 10 percent below nameplate rating. Where shown on the drawings or required in the specifications to be operated on a reduced voltage motor starter or variable frequency drive, the motor shall develop ample torque under the conditions imposed by the starting method.
- B. Motors shall not be required to deliver more than its rated nameplate horsepower, at unity (1.0) service factor, under any condition of mechanical or hydraulic loading.
- C. All motors shall be continuous time rated for operation at 40 degrees C ambient and altitudes less than 1,000 meters unless noted otherwise.
- D. Specific motor data such as horsepower, RPM, etc., is specified under the detailed specification for the mechanical equipment with which the motor is supplied.

- E. Where shown on the drawings motors install in the classified areas or hazardous location in area where a fire and/or explosion hazard may exist due to flammable gasses or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated for the applications.
- F. Provide 3-pole and/or 6-pole motors as shown on drawings.

2.2 THREE PHASE MOTORS

A. General

1. Unless otherwise specified, motors 1/2 horsepower and larger shall be 3-phase, squirrel cage induction type
2. Motors shall be designed and connected for operation on a 480 volt, 3 phase, 60 hertz alternating current system. Dual voltage (230/460) rated motors are acceptable; tri-voltage (200/230/460) rated motors are not acceptable.
3. Unless otherwise required by the load, all polyphase motors shall be premium efficiency NEMA Design B and provide normal starting torque. Locked rotor kVA/HP shall not exceed Code Letter G as described in NEMA Standard MG1-10.37 for motors 20 HP and larger.
4. Unless otherwise specified in the driven equipment specifications, vertical motors shall be provided in the vertical solid shaft configuration.
5. Polyphase motors for use with variable frequency drives shall be rated as definite-purpose inverter fed as defined under NEMA MG-1, Part 31.
6. Provide a shaft grounding ring for all VFD-driven motors regardless of size.
7. For VFD-driven motors larger than 100 HP, provide an insulated bearing on the opposite drive end of the motor in order to break the circulating bearing current path.
8. Where variable frequency drive (VFD) and inverter duty motor are used a ground ring or equivalent hardware shall be incorporated into the system to mitigate pitting and fluting of motor shaft and bearing result from high voltage and frequency switching from VFD. The ring shall be made of special engineered conductive microfibers to redirect shaft current and provide a reliable, very low impedance path from shaft to frame, bypassing the motor bearings entirely.

B. Required features and accessories

1. Motors one horsepower and above shall have the following IEEE-841 features:
 - a. Premium efficiency
 - 1) Include thrust-bearing losses in the motor efficiency calculation.
 - b. Corrosion resistant cast iron construction with TEFC enclosure.
 - c. Non-wearing, non-contacting, radial-axial labyrinth bearing isolator (INPRO/SEAL) on both ends for a horizontal motor
 - d. Non-wearing, non-contacting, radial-axial labyrinth bearing isolator (INPRO/SEAL) on the shaft extension end for a vertical motor
 - e. 1.15 service factor
 - f. Ground lug in conduit box
 - g. Ground terminal on frame
 - h. Class F insulation with Class B (80 deg C) rise at 1.0 Service Factor for TEFC enclosures (Resistance Method)
 - i. Special (“refined”) balance – 0.08 inches/second peak maximum vibration
 - j. Special shaft run-out (“1/2 NEMA”) tolerance – 0.001 inches maximum
 - k. Oversized main conduit box
 - l. NEMA Design B
 - m. Non-witnessed IEEE 841 enhanced no-load test.
 - n. AFBMA bearing numbers stamped on the motor nameplate.
 - o. 50,000 hour bearing L-10 life.
 - 1) The driven equipment supplier shall provide thrust loads to the motor supplier.
 - p. Warranty
 - 1) For Frame 447 and smaller: five years from date of installation.

- 2) For Frame 449 and larger: two years from date of installation.
2. Provide insulation treatment of two cycles of vacuum pressure impregnation of 100% solid epoxy resins. Insulation treatment shall meet the NEMA definition for moisture-resistant winding per NEMA MG1-1.27.1
 3. For motors 40 hp and larger, provide a separate, dedicated, accessory conduit terminal box with terminal strip connectors to terminate the leads of space heaters and thermal protection devices.
 4. Provide 120 V single-phase space heaters for all three-phase motors.
 5. Thermal protection
 - a. Motors < 250 hp
 - 1) Provide factory installed, embedded, bi-metallic temperature switches with leads terminating in the main conduit box or separate accessory conduit box, where specified herein. The switches shall have normally closed contacts. Provide three detectors for each motor, one switch per phase. These devices shall protect the motor against damage from overheating caused by single phasing, overload, high ambient temperature, abnormal voltage, locked rotor, frequent starts or ventilation failure.
 - b. Motors 250 hp and larger
 - 1) Stator winding
 - a) Provide two resistance temperature detectors (RTDs) per phase, six per motor. RTDs shall be three-wire, platinum, 100 ohms. Connect leads to terminal strip connectors in an accessory conduit box.
 - 2) Bearings
 - a) Provide one resistance temperature detector (RTD) per bearing, two per motor. RTDs shall be three-wire, platinum, 100 ohms. Connect leads to terminal strip connectors in an accessory conduit box.

6. Finishes
 - a. For distribution pumping plant applications, provide safety yellow enamel exterior finish coating, Federal Standard color No. 13591.
 - b. For all other applications, provide safety orange enamel exterior finish coating, ANSI Munsell Spec 5.0YR-6.0/15.

C. Acceptable manufacturers:

1. U.S. Electrical Motors Division of Emerson Electric Co.
2. Baldor
3. Or equal.

D. Fractional Horsepower Motors:

1. Fractional horsepower motors shall be premium-efficiency type, TEFC, with a 1.15 service factor.

E. Motors One Horsepower and Above:

1. Motors one horsepower and above shall meet or exceed the requirements of IEEE 841.

2.3 SINGLE-PHASE MOTORS

- A. Unless otherwise specified, motors smaller than 1/2 horsepower shall be single phase, capacitor start, with TEFC enclosure. Small fan motors may be split-phase or shaded pole type if such are standard for the equipment. Wound rotor or commutator type single-phase motors are not acceptable unless their specific characteristics are necessary for the application.
- B. Motors shall be rated for operation at 115 or 208 volts, single phase, 60 Hz.
- C. Locked rotor current shall not be greater than specified in NEMA Standard MG1-Part 12, Design "N".
- D. Motors shall be totally-enclosed in conformance with NEMA Standard MG1-Part 1.
 1. Motors shall be provided with sealed ball bearings lubricated for 10 years normal use.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install all motors in accordance with the manufacturer's printed recommendations and as required under the specific specification sections for the driven equipment.
- B. Bolt the motor to the equipment or rigid foundation using bolts of the largest size permitted by the holes in the motor bracket. Do not install motors in such a way as to restrict motor ventilation.

3.2 PREPARATION

- A. Inspect, clean, and restore the motor to the “as-shipped” condition.
- B. If the motor has been subject to vibration during storage, disassemble and inspect each bearing for damage.
- C. When storage time has been six months or more, change the lubrication (oil and/or grease). For motors with oil lubricated bearings, do not move the motor with oil in the reservoir.

3.3 INSTALLATION

- A. Motors shall be stored indoors in a clean, dry location.
- B. Bolt the motor to the equipment or rigid foundation using bolts of the largest size permitted by the holes in the motor bracket. Do not install motors in such a way as to restrict motor ventilation.

3.4 FIELD QUALITY CONTROL

- A. Submit field test procedures for the Engineer’s approval before testing begins. Test and submit test results for each motor.
- B. Field tests and inspections:
 - 1. Field testing shall be as specified in Section 26 08 00.

END OF SECTION

IEEE-841 Data Sheet for AC Squirrel Cage Induction Motors [370 kW (500 hp) and below]

| | | |
|---------------|-----------------|-----------|
| Client | Engineering Org | Spec. No. |
| Project Title | Location | Date |
| Location | Contract No. | Equip No. |
| Unit | Specifier Name | Tele. No. |
| | | P.O. No. |

| | |
|--|---|
| <p>Data Provided by: <input type="checkbox"/> Buyer with Request for Quotes • Seller with Proposal ◇ Seller After Order</p> <p>Site Conditions:</p> <p><input type="checkbox"/> Altitude: _____ m</p> <p><input type="checkbox"/> Ambient Temp.: Max _____ °C <input type="checkbox"/> Min _____ °C</p> <p><input type="checkbox"/> Area Class _____ Div _____ Group _____</p> <p><input type="checkbox"/> Nonhazardous <input type="checkbox"/> Auto Ignition Temp _____ °C</p> <p>Data Supplied by User:</p> <p><input type="checkbox"/> Power: _____ kW _____ hp</p> <p><input type="checkbox"/> Synchronous Speed: _____</p> <p><input type="checkbox"/> Voltage: _____</p> <p><input type="checkbox"/> Phase: 3</p> <p><input type="checkbox"/> Frequency: 60 Hz</p> <p><input type="checkbox"/> Insul. System: Random/Form Wound (see note below)</p> <p><input type="checkbox"/> Enclosure: TEFC TENV</p> <p><input type="checkbox"/> Coupled Drive: Direct/Belt</p> <p><input type="checkbox"/> Mounting Position: Horizontal/Vertical</p> <p><input type="checkbox"/> Shaft Up or Down (Vertical Mtg. Only)</p> <p>_____</p> <p><input type="checkbox"/> Service Factor: (see note below) _____</p> <p><input type="checkbox"/> Motor Thrust Loads: _____</p> <p><input type="checkbox"/> Special Load Conditions: _____</p> <p>_____</p> <p><input type="checkbox"/> Space Heaters: _____</p> <p><input type="checkbox"/> Space Heater Maximum Surface Temperature: _____ °C</p> <p><input type="checkbox"/> Space Heater Leads Location: _____</p> <p><input type="checkbox"/> Rotation Direction: _____</p> <p><input type="checkbox"/> Starting Method: _____</p> <p><input type="checkbox"/> Main Terminal Box Location: _____</p> <p>_____</p> <p><input type="checkbox"/> Other Data: (Bearing type, lubrication method, motor mounting information, unusual service conditions, etc.)</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>NOTES:</p> <p>1) Motor should be applied within its rating based on service factor of 1.0.</p> <p>2) Motor insulation system:</p> <ul style="list-style-type: none"> - Random wound 600 V class for kW (hp) < 190 (250) - Random/form wound 600 V class for kW (hp) > 150 (200) - Form wound 2300 V and 4000 V | <p>Data Supplied by Manufacturer:</p> <p>• Frame Size: _____</p> <p>• Full Load Speed: _____ rpm</p> <p>• Full Load Current: _____</p> <p>◇ Locked Rotor Current @ Full Voltage: _____</p> <p>◇ Locked Rotor Current @ 90% Voltage: _____</p> <p>• Allowable Stall Time @ Full Voltage: _____</p> <p>• Allowable Stall Time @ 90% Voltage: _____</p> <p>• Sound Power Level (No Load): 90 dBA (max.) _____</p> <p>• Insulation System:</p> <p style="padding-left: 20px;">Class F Minimum: _____</p> <p style="padding-left: 20px;">Random/Form Wound: _____</p> <p>• Temperature Rise at Rated Load: _____ °C Max.</p> <p>• Service Factor: (see note below) _____</p> <p>• Motor Terminal Leads: _____</p> <p>Bearing Information:</p> <p>• Type: _____</p> <p>• Lubrication Method: _____</p> <p>◇ Recommended Lubricant: _____</p> <p>• Temp. Rise @ Full Load: _____</p> <p>_____</p> <p>◇ Manufacturer & Number: _____</p> <p style="padding-left: 40px;">ODE _____ DE _____</p> <p>• Motor Guaranteed Min. Eff. @ Full Load: _____</p> <p>• Terminal Box(es) Materials of Construction: _____</p> <p>_____</p> <p>• Fan Material: _____</p> <p>• Space Heater Term. Box Location: _____</p> <p>• Space Heater Max. Sheath Temperature: _____</p> <p>_____</p> <p>• Other Data: _____</p> <p>_____</p> <p>Shop Inspection & Tests:</p> <p><input type="checkbox"/> Shop Inspection Required: (Yes/No) _____</p> <p>_____</p> <p><input type="checkbox"/> Final Tests Witnessed by Customer: (Yes/No) _____</p> <p><input type="checkbox"/> Other Special Tests: _____</p> <p>_____</p> <p>_____</p> <p>_____</p> |
|--|---|

SECTION 26 08 00

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:

1. Perform field tests as herein specified by a certified, independent Testing Firm as specified herein. The Testing Firm shall provide all material, equipment, labor, and technical supervision to perform such tests.
2. It is the intent of these tests to assure that all electrical equipment supplied is operational and within industry and manufactures tolerances and is installed in accordance with manufacturer's design and specifications.
3. The Testing Firm shall maintain a written record of the tests and upon completion of project, assemble and certify a final test report for review by the District.

1.2 QUALITY ASSURANCE

A. Experience:

1. The Testing Firm shall be a corporately independent testing organization which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems evaluated by the Testing Firm.
2. The Testing Firm shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.
3. The Testing Firm shall have been engaged in such practices for a minimum of five years.
4. The Testing Firm shall meet federal OSHA criteria for accreditation of testing laboratories, Title 29, Parts 1907, 1910, and 1936. Full membership in the InterNational Electrical Testing Association (NETA) constitutes proof of such criteria.
5. The lead, on-site technical person shall be currently certified by the NETA in Electrical Power Distribution System Testing. Submit copy of qualifications and certifications for review by the District.
6. Testing firm shall utilize only full-time technicians who are regularly employed by the firm for testing services. Electrically unskilled employees are not permitted to perform testing or assistance of any kind. Electricians or linemen may assist but may not perform testing or inspection services.

7. The Testing Firm shall submit proof of the above qualifications with bid documents when requested.
8. The Testing Firm shall be an independent organization as defined by OSHA Title 29, Part 1936, and the NETA.
9. All instruments used by the Testing Firm to evaluate electrical performance shall meet NETA's Acceptance Testing Specifications for Calibration of Test Instruments.
10. The Testing Firm shall be:
 - a. Power Systems Testing Co., Hayward, California
 - b. Pacific Power Testing, San Leandro, California
 - c. Apparatus Testing and Engineering, Rancho Cordova, California
 - d. Associated Power Solutions, Concord, California
 - e. Or equal.

1.3 SUBMITTALS

- A. The Contractor shall furnish submittals for approval as outlined below:
 1. Proposed field acceptance tests
 2. Field acceptance test reports
 3. List of proposed testing equipment

1.4 REFERENCES

- A. InterNational Electrical Testing Association (NETA)

1.5 SCHEDULING

- A. Notify the Testing Firm when equipment becomes available for acceptance tests. Coordinate Work with other systems.
- B. Notify the District a minimum of two week prior to commencement of any testing.

1.6 SYSTEM DESCRIPTION

A. Performance requirements

1. Testing and calculations required under this Section shall be per the guidelines specified in the most recent NETA publication “Acceptance Testing Specification for Electric Power Distribution Equipment and Systems”.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

- A. Perform general equipment inspection and checking procedures recommended by the manufacturer and as specified in other Sections of these specifications prior to and in addition to tests performed by the Testing Firm specified herein.
- B. Supply a suitable and stable source of electrical power to each test site. The Testing Firm shall specify the specific power requirements.
- C. Any system, material, or workmanship which is found defective on the basis of acceptance tests shall be reported, corrected and retested all at no additional cost to the District.
- D. Exiting arc flash category of the MCC P40, P42, P43 are Category 2 or less when the equipment is energized. Contact the District for additional information.

3.2 FIELD QUALITY CONTROL

A. Site Testing

1. Testing and commissioning shall be performed in accordance with the latest revision of NETA ATS “Acceptance Testing Specifications” Standard for Electrical Power Distribution Equipment and Systems.
2. Perform testing in two separate phases. Submit a typed report after each testing phase is completed. Submit the report to the District for review, comment, and record purposes. All reports submitted by the Testing Firm shall meet NETA's ATS for Test Reports.
3. The report shall include a data sheet for each component (i.e., cable, circuit breaker, transformer, relay, motor, etc.) tested. Include in each data sheet the weather conditions at the time of the test (i.e., temperature, humidity, sunny, rain, etc.) the tester’s observation and findings, discrepancies, any remedial work performed or act to resolve problems, technical parameters obtained during the tests, as left settings of all devices, and a statement indicating the equipment is ready to be energized. The report shall contain a statement indicating the equipment was tested in

accordance with the procedures outlines in the latest editions of the NETA's ATS.

B. Shop Testing

1. Only the equipment listed in Table 1 are permitted to be tested at a local shop prior to MCC bucket installation in order to minimize District shut down time.

| <u>Table 1: Testing Summary</u> <u>(Additional tests may be required in other specification sections)</u> | |
|--|--|
| <u>System/Equipment Name</u> | <u>Associated Circuit Breaker Location</u> |
| <u>MCC- P40</u> | <u>1FR, 3KL, 3KR,3ML, 3MR</u> |
| <u>MCC-P42</u> | <u>1F</u> |
| <u>MCC-P43</u> | <u>4F, 6FR, 7KL, 7KR, 7ML, 7 MR</u> |

C. Phase 1 – Testing requirements to be performed before the equipment is energized.

1. Inspect and mechanically operate all circuit breakers, power disconnect switches, transfer switches, and circuit breakers/disconnect switches installed within equipment furnished under other divisions of these specifications.
2. Set, calibrate and test all protective devices including but not limited to, circuit breakers, protective relays, timing devices, motor overload per Protective Device Selective Coordination Study.
3. Verify that protective relay, current transformers, ground sensing devices, transformer grounding resistors, fuses, interrupter switches, transfer switches, transformers and motor starters furnished are in accordance with the approved shop drawings and the Protective Device Selective Coordination Study.
4. Test all low voltage (less than 600V) power system cables as specified under Section 26 05 19 Low Voltage Electrical Power Conductors and Cables.
5. Set motor circuit protectors. Adjust the settings to lowest setting that will allow the motor to be started when under load conditions. In no case shall the setting exceed that allowed by the CEC.

6. Verify that all power and control power fuses installed are in accordance with the manufacturer's approved shop drawings, the Protective Device Selective Coordination Study, and the CEC. Replace fuses found to be of the incorrect rating.
7. Verify control circuits and functionality of the controls for all motors, automatic transfer systems, remote protective device (i.e., wiring for differential protection relays, variable frequency drives, alarms systems, safety interlocks emergency stop controls, motor, transformer, and generator protective devices). The functionality shall be in accordance with the approved control schematics, wiring diagrams or functional descriptions.
8. Check motor nameplates for correct phase and voltage. Verify motor bearings for proper lubrication.
9. Inspect each piece of electrical equipment in areas designated as NEMA 4 or NEMA 4X to ensure that equipment of proper rating is installed.
10. Verify all lightning and surge arrestors, service entrance equipment, power distribution equipment, motors, control centers, utilization equipment, etc., are properly grounded.
11. Verify the resistance to ground of all power distribution equipment is 5 ohms or less.
12. Verify all terminations at the transformers, service entrance and distribution switchgear/switchboards, motor control centers, panelboards and motors are correctly made and properly torqued.
13. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points. Verify the resistance is 0.5 ohms or less.
14. Refer to the individual equipment and material specification sections for additional testing requirements.
15. Verify all circuit breaker ratings and settings are as required by the Contract Documents or as amended during shop drawing review. Advise the District of discrepancies and make changes as directed by the District.
16. Verify proper operation of automatic transfer switches, accessories devices and motor interlocks.
17. Assist in the testing of the standby engine generator(s).
18. Verify grounding of instrumentation equipment and line surge protection equipment.

19. Provide test report as specified in Paragraph A.2 above. Report shall be reviewed and approved by the District.
- D. Phase 2 - After the electrical distribution equipment has been energized perform the following tests:
1. Verify phase rotation at the service entrance, distribution switchgear, motor control centers, and panelboards.
 2. Adjust the taps on the transformers to produce the nominal voltage at the secondary terminals of the transformers as shown on the drawings.
 3. Jog all motors to verify rotation. Disconnect the driven equipment if damage could occur due to incorrect rotation. If the rotation is found to be incorrect, reconnect the motor terminations at the motor terminal box.
 4. Check all instrument wiring and verify grounding is in accordance with the manufacture's recommendations.
 5. Check the full load current draw of each motor. Where power factor correction capacitors are provided, the capacitor shall be in the circuit at the time of the measurement. Compare the measured value to the rating of the thermal overload devices furnished and verify compliance with the CEC.
 6. Submit a typed list record for each motor. The list shall include the motor name and number, the MCC and MCC bucket to which the motor is connect, the overload rating, and the motor circuit protector rating and setting. The rating and setting of the overload device and the motor circuit protector shall be compared to the ratings allowed by the CEC.
 7. The Testing Company shall obtain the approved/corrected Protective Device Selective Coordination Study before starting the testing and shall become familiar with the Study. All discrepancies shall be addressed before the testing begins.
 8. Submit a typed report as specified in Paragraph A.2 above. The report shall be stamped and signed by a California Registered Professional Engineer.

3.3 GROUNDING SYSTEMS

- A. Grounding Systems specified in Section 26 05 26 shall be field inspected and tested as follows:
 - 1. Perform all standard visual and mechanical inspections and electrical tests listed in NETA ATS, paragraph 7.13 for Grounding Systems:
 - a. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, derived neutral points.

3.4 LOW VOLTAGE CABLES

- A. Low Voltage Control Cable specified in Section 26 05 19 shall be field inspected and tested as follows:
 - 1. Perform all standard visual and mechanical inspections and electrical tests listed in NETA ATS, paragraph 7.3.2 for Low Voltage Cables:
 - a. Inspect bolted electrical connections for high resistance by verifying the tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
 - b. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for >600 volt rated cable. Test duration shall be one minute.
 - 2. Perform the following additional electrical tests on shielded control cable:
 - a. Inspect shield grounding, cable support, and termination.
 - b. Perform a shield-continuity test on each cable by ohmmeter method.

3.5 LOW VOLTAGE MOTOR CONTROLLERS

- A. Low Voltage Motor Controllers specified in Sections 26 29 13.13 Across-the-Line Motor Controllers shall be field inspected and tested as follows:
 - 1. Perform all standard visual and mechanical inspections and electrical tests listed in NETA ATS, paragraph 7.16.1.1 for Low-Voltage Motor Starters.
 - a. Inspect bolted electrical connections for high resistance by verifying the tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.

2. Perform the following optional visual and mechanical inspections listed in NETA ATS, paragraph 7.16.1.1 for Low-Voltage Motor Starters:
 - a. Motor-Running Protection
3. Perform the following optional electrical tests listed in NETA ATS, paragraph 7.16.1.1 for Low-Voltage Motor Starters:
 - a. Perform insulation-resistance test all control wiring with respect to ground. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute. Perform surge comparison tests. For units with solid-state components, follow manufacturer's recommendations.
 - b. Perform system function test in accordance with NETA ATS, section 8, System Functional Tests.

3.6 LOW VOLTAGE CIRCUIT BREAKERS

- A. All Low Voltage Circuit Breakers shall be field inspected and tested as follows:
 1. Perform all standard visual and mechanical inspections and electrical tests listed in NETA ATS, paragraph 7.6.1.1 for Low-Voltage Insulated/Molded Case Circuit Breakers.
 - a. Inspect bolted electrical connections for high resistance by verifying the tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
 2. Perform the following optional electrical test listed in NETA ATS, paragraph 7.6.1.1 for Low-Voltage Insulated/Molded Case Circuit Breakers:
 - a. Perform insulation-resistance test all control wiring with respect to ground. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute. Perform surge comparison tests. For units with solid-state components, follow manufacturer's recommendations.

3.7 LOW VOLTAGE MOTORS

- A. Low voltage motors specified in Section 26 05 83 shall be field inspected and tested as follows:
 1. Perform test in accordance with Section 26 05 83 Low Voltage Motors.

2. Perform all standard visual and mechanical inspections and electrical tests listed in NETA ATS, paragraph 7.15.1 for Rotating Machinery, AC Motors:
 - a. Inspect bolted electrical connections for high resistance by verifying the tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.

END OF SECTION

SECTION 26 24 19

MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:

1. Furnish, install and test the motor control center buckets for existing Motor Control Center as shown on the drawings in accordance with these specifications.
2. Motor control center buckets shall be sized to include all equipment, spares and spaces as shown on the drawings.

B. Related sections:

1. Section 01 43 11 – Seismic Requirements
2. Section 26 05 00 - Common Work Results for Electrical
3. Section 26 05 26 – Grounding and Bonding for Electrical Systems
4. Section 26 05 53 - Identification of Electrical Systems
5. Section 26 08 00 - Commissioning of Electrical Systems

1.2 QUALITY ASSURANCE

- A. The motor control centers shall be the same make product of a manufacturer who shall also be the manufacturer of all the circuit breakers, fused switches and motor starters included in the motor control centers.
- B. Motor control centers shall be designed, assembled and tested by a UL listed and certified system integrator shop.
- C. Equipment construction shall be UL-845 listed meeting NEMA ICS 18 standards.

1.3 SUBMITTALS

- A. Submit shop drawings and product data, in accordance with Section 01 33 00.
- B. The Contractor shall furnish submittals for approval as outlined below:
 1. Motor Control Centers modifications
 - a. Equipment outline drawings showing elevation and plan views, and dimensions. Indicate all options, special features, ratings and deviations from the specifications.

- b. Unit summary tables showing detailed equipment description and nameplate data for each compartment
- c. Product data sheets and catalog numbers for overcurrent protective devices, motor starters, control relays, control stations, meters, pilot lights, etc. List all options, trip adjustments and accessories furnished specifically for this Work.
- d. Instruction and renewal parts books
- e. Itemized list of spare parts furnished specifically for this Work, including quantities, description and part numbers.
- f. Protective device time-current characteristics
- g. Provide single line diagram and interconnection diagrams showing wire and terminal identification numbers.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Refer to Common Work Results for Electrical, Section 26 05 00.

1.5 REFERENCE STANDARDS

- A. Motor control centers shall be designed, built and tested in accordance with the latest editions and revisions of NEMA Standard ICS-2 and Underwriters' Laboratories Standard No. UL-845. Equipment shall conform to ANSI C19.3 test standards and the requirements of the National Electric Code and IEEE C37.20.7.
- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.6 JOB CONDITIONS

- A. Refer to Common Work Results for Electrical, Section 26 05 00.

PART 2 - PRODUCTS

2.1 EXISTING MOTOR CONTROL CENTERS DATA

- A. MCC-P40
 - 1. Ratings
 - a. Service: 800A, 480 volt, 3 phase, 3 wire, 60 Hertz.
 - b. The overall short circuit withstand and interrupt current rating of the equipment and devices shall be 65,000 rms Section 1-4 600A vertical bus
 - c. Section 1-4 600A vertical bus

- d. Section 5, 7 800A vertical bus
- e. Section 6 no vertical bus
- 2. Manufacturer:
 - a. Eaton Corp. "Freedom 2100"
 - b. MSF0003846 IT.018 – POC
 - c. 03/10
- B. MCC-P41
 - 1. Ratings
 - a. Service: 800A, 480 volt, 3 phase, 3 wire, 60 Hertz.
 - b. The overall short circuit withstand, and interrupt current rating of the equipment and devices shall be 65,000 rms Section 1-4 600A vertical bus
 - c. Section 4-7 600A vertical bus
 - d. Section 1, 3 800A vertical bus
 - e. Section 2 no vertical bus
 - 2. Manufacturer:
 - a. Eaton Corp. "Freedom 2100"
 - b. G.O. MSF0003846 IT.019 – POC
 - c. Fabrication Date 03/10
- C. MCC-P42
 - 1. Ratings
 - a. Service: 800A, 480 volt, 3 phase, 3 wire, 60 Hertz.
 - b. The overall short circuit withstand, and interrupt current rating of the equipment and devices shall be 65,000 rms Section 1-4 600A vertical bus
 - c. Section 1-4 600A vertical bus
 - d. Section 5, 7 800A vertical bus
 - e. Section 6 no vertical bus

2. Manufacturer:
 - a. Eaton Corp. "Freedom 2100"
 - b. G.O. MSF0003846 IT.020 – POC
 - c. Fabrication Date 03/10

D. MCC-P43

1. Ratings
 - a. Service: 800A, 480 volt, 3 phase, 3 wire, 60 Hertz.
 - b. The overall short circuit withstand, and interrupt current rating of the equipment and devices shall be 65,000 rms Section 1-4 600A vertical bus
 - c. Section 4-7 600A vertical bus
 - d. Section 1, 3 800A vertical bus
 - e. Section 2 no vertical bus
2. Manufacturer:
 - a. Eaton Corp. "Freedom 2100"
 - b. G.O. MSF0003846 IT.021 – POC
 - c. Fabrication Date 03/10

2.2 COMPONENTS

A. General

1. The drawings indicate the approximate horsepower and intended control scheme of the motor driven equipment. Provide the NEMA size starter, circuit breaker trip ratings, and control power transformers ratings matched to the motors and control equipment actually supplied, in compliance with the National Electrical Code.
2. Make and model of new breakers, MCP, motor starter, etc. shall match existing MCC part numbers.
3. Surface Preparation and Shop Coatings
 - a. All non-current carrying metal parts of the control center assembly shall be cleaned of all weld spatter and other foreign material and given a heat cured, phosphatized chemical pre-treatment to inhibit rust.

- b. Indoor equipment shall be finish painted with one coat of manufacturers standard electrocoated, heat cured enamel.
 - c. Unpainted non-current carrying parts shall receive a protective zinc plating to prevent corrosion.
 - B. Feeder Circuit Breaker
 - 1. Protective devices shall be molded case circuit breakers with inverse time and instantaneous tripping characteristics.
 - 2. Circuit breakers shall have the following minimum symmetrical interrupting capacity of 65,000 amperes for 480V systems, unless otherwise indicated on the drawings.
 - 3. 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.
 - 4. Circuit breaker shall have label indicating “Line” and “Load” of the incoming and outgoing terminals.
 - 5. Manufacturer:
 - a. Eaton HFD.
 - C. Spare Parts
 - 1. Provide the following spare parts in the quantities specified for motor control centers and switchboards:
 - a. 50 percent replacement fuses, all types and sizes.
 - 2. Spare parts shall be boxed or packaged for long term storage. Identify each item with manufacturers name, description and part number on the exterior of the package.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Field installed interior wiring shall be neatly grouped by circuit and bound by plastic tie wraps. Support circuit groups so that circuit terminations are not stressed.
- B. In general, all conduit entering or leaving a motor control center shall be stubbed into the bottom or top horizontal wireway directly below or above the vertical section in which the conductors are to be terminated.

- C. Install the equipment in accordance with the manufacturer's instructions.
- D. Touch-up damaged paint finishes.

3.2 FACTORY QUALITY CONTROL

- A. The motor control center shall be tested per the manufactures standard factory tests.
- B. Contractor shall provide factory test report to the District for review and approval.

3.3 FIELD QUALITY CONTROL

- A. The Contractor shall make provisions for acceptance testing per the requirements of Section 26 08 00.
- B. NETA testing of MCC breakers and buckets shall be tested at the system integrator's shop or alternative agreed upon local location. The Contractor shall notify the District two weeks advance of all tests. Testing shall consist of no less than one (1) 8-hour days. The Contractor shall pay for all District travel expenses for one (1) District employee related to the inspection and witness testing including hotel fee, airfares, rental car fees, and meals.
- C. In the event of an equipment fault, notify the Engineer immediately. After the cause of the fault has been identified and corrected, a joint inspection of the equipment shall be conducted by the Contractor, the Engineer and the equipment manufacturer's factory service technician. Repair or replace the equipment as directed by the Engineer prior to placing the equipment back into service.
- D. All as-built drawings shall be corrected and verified for correctness of in-field changes by the Contractor prior to submittal to the Engineer for final review.

3.4 CLEANING

- A. Remove all rubbish and debris from inside and around the motor control center. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint-free rags. Do not use compressed air.

END OF SECTION

SECTION 26 29 13.13

ACROSS-THE-LINE MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:

1. Furnish, install and test low voltage enclosed across-the-line combination motor starters and manual motor starters as shown on the drawings in accordance with these specifications.

B. Related sections:

1. Section 01 75 17 – Field Testing and Startup
2. Section 26 05 00 – Common Work Results for Electrical
3. Section 26 08 00 – Commissioning of Electrical Systems

1.2 SUBMITTALS

A. The Contractor shall furnish submittals for approval as outlined below:

1. Product Data
2. Warranty
3. Bill of Materials
4. Manufacturer's nameplate data
5. Dimensions (elevations, plan views, sections)
6. Schematic (elementary) diagrams and wiring diagrams
7. Interconnection wiring diagrams
8. Seismic anchorage calculations
9. As-built documentation
10. Certified factory test reports
11. Proposed field functional tests
12. Field functional test reports

1.3 REFERENCE STANDARDS

- A. NEMA ICS-2 – Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated 600 Volts.
- B. UL 508 – Industrial Control Equipment.

PART 2 - PRODUCTS

2.1 ENCLOSED COMBINATION MOTOR STARTERS

A. General:

- 1. The drawings indicate the approximate horsepower and intended control scheme of the motor driven equipment. Provide the NEMA size starter, circuit breaker trip ratings, and control power transformers ratings matched to the motors and control equipment actually supplied. All variations necessary to accommodate the motors and controls as actually furnished shall be made without extra cost to the District.
- 2. The enclosed combination motor starter shall be Type NEMA 4X, SS316.

B. Components:

- 1. Provide enclosed 600 volt single and three phase across-the-line non-reversing combination motor starters manufactured in accordance with the latest NEMA standards.
- 2. Starters shall include a side-mounted operating handle, thermal magnetic circuit breaker or motor circuit protector (MCP) in series with a magnetic starter, overload protective device, control power transformer, selector switches, pushbuttons, indicating lights, control relays, and terminal blocks contained inside a NEMA 4X enclosure.
- 3. The operating handle shall always remain connected to the circuit breaker or MCP. The handle shall not be mounted in the front door of the enclosure, but to the side of the door for safe stand-aside operation. Position of the handle shall indicate ON, OFF, or TRIPPED condition of the circuit breaker or MCP. Mechanical interlock provisions shall not permit unauthorized opening of the enclosure door with the operating handle in the ON position. The operating handle shall be capable of being padlocked while in the OFF position.
- 4. Circuit breakers shall be molded case bolt-on type with fixed thermal magnetic trips.
- 5. Provide MCP's, motor starters, motor overload protection, auxiliary contacts, control power transformers, control relays and timers, and pilot devices as specified below.

6. Auxiliary contacts: Form C, NEMA A600 rating, as required by the control schemes on the drawings. Provide 1-normally open and 1-normally closed spare contacts on each starter. Furnish additional auxiliary contacts as shown on the drawings or as required by the control schematic and specifications.
 7. Control power transformers: Two winding type, 120 VAC secondary, with primary and secondary fuses in accordance with the CEC. Provide a minimum 50 percent extra capacity.
 8. Control relays and timers: 300 volt, industrial rated, plug-in socket type, housed in a transparent polycarbonate dust cover, designed in accordance with UL Standard 508 for motor controller duty. Continuous contact rating shall be 10 amperes resistive, 1/4 HP, at 120 VAC, operating temperature minus 10 to plus 55 degrees C. Relays and timers shall be Potter & Brumfield KRP Series or equal as approved by the Engineer with neon coil indicator light and calibrated timing knob or DIP settable controls.
 9. Elapsed time hour meter: Five digit, non-reset type, with 120-volt synchronous motor.
- C. Provide for remote control interlocks as shown on the drawings.
- D. Acceptable manufacturers:
1. Eaton
 2. Allen-Bradley
 3. General Electric
 4. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Starters shall be firmly bolted to the appropriate surface per approved shop drawings.
- B. Provide equipment anchorage in accordance with the approved seismic calculations.

3.2 FIELD QUALITY CONTROL

- A. Field testing shall be as specified in Section 26 08 00.

END OF SECTION