MACON WATER AUTHORITY

CONTRACT FOR

Lower Poplar Water Reclamation Facility
Influent Pump Station

Volume 2 of 2

REVISED SEPTEMBER 2024
(TO INCORPORATE ADDENDA ITEMS)

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Part 1 General

1.1 Work Included

A. Demolition of designated structures, foundations, below-grade structural features, mechanical equipment, electrical equipment, utilities, and other existing facilities.

B. Unless otherwise noted, remove all demolition material from the project site and properly dispose of all demolition material at a location selected and provided by the Contractor.

1.2 Related Sections

A. Section 01 11 00 - Summary of Work.

1.3 Demolition Plan

A. Prepare a Demolition Plan and submit proposed demolition and removal procedures for approval before work is started. Include in the plan procedures for careful removal and disposition of materials specified to be salvaged, coordination with other work in progress, a disconnection schedule of utility services, and a detailed description of methods and equipment to be used for each operation. Plan shall be approved by the Owner prior to work beginning.

B. General Requirements: Do not begin demolition or deconstruction until authorization is received from the Owner. Remove rubbish and debris from the project site; do not allow accumulations. Store materials that cannot be removed daily in areas agreed upon by the contractor and the Owner.

1.4 Items to Remain in Place

A. Take necessary precautions to avoid damage to existing items to remain in place, to be reused, or to remain the property of the Owner. Repair or replace damaged items as approved by the Engineer. Coordinate the work of this section with all other work indicated.

B. Do not overload pavements to remain.

C. Existing Construction Limits and Protection: Do not disturb existing construction beyond the extent indicated or necessary for installation of new construction. Provide protective measures to control accumulation and migration of dust and dirt in all work areas. Remove dust, dirt, and debris from work areas daily.

1. Utility Service: Maintain existing utilities indicated to stay in service and protect against damage during demolition and deconstruction operations. Prior to start of work, utilities serving each area of alteration or removal will be shut off by the Owner and disconnected and sealed by the Contractor.

D. Facilities:

1. Protect electrical and mechanical services and utilities. Where removal of existing utilities and pavement is specified or indicated, provide approved barricades, temporary covering of exposed areas, and temporary services or connections for electrical and mechanical utilities.

2. Floors, roofs, walls, columns, pilasters, and other structural components that are designed and constructed to stand without lateral support or shoring, and are determined to be in stable condition, must remain standing without additional bracing, shoring, or lateral support until demolished, unless directed otherwise by the Engineer. Ensure that no elements determined to be unstable are left unsupported and place and secure bracing, shoring, or lateral supports as may be required as a result of any cutting, removal, or demolition work performed under this contract.

1.5 Burning

A. The use of burning at the project site for the disposal of refuse and debris will not be permitted.

1.6 Submittals

A. Submit the following in accordance with Section 01 33 00 - Submittal Procedures.

B. Existing Conditions Survey

C. Demolition Plan

1.7 Quality Assurance

A. Comply with federal, state, and local hauling and disposal regulations.

B. Use of explosives will not be permitted.

C. Dust Control: Prevent the spread of dust and debris to occupied portions of the building and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to, ice, flooding, or pollution.

1.8 Existing Conditions

A. Before beginning any demolition or deconstruction work, survey the site and examine the drawings and specifications to determine the extent of the work. Record existing conditions in the presence of the Engineer showing the condition of structures and other facilities adjacent to areas of alteration or removal. Photographs sized 4 inch by 6 inch or electronic photographs of equivalent resolution will be acceptable as a record of existing conditions. Include in the record the elevation of the top of foundation walls, finish floor elevations, possible conflicting electrical conduits, plumbing lines, alarms systems, the location and extent of existing cracks and other damage and description of surface conditions that exist prior to before starting work. It is the Contractor's responsibility to verify and document all required outages which will be required during the course of work, and to note these outages on the record document.

Part 2 Products

(NOT USED)

Part 3 Execution

3.1 Existing Facilities to be Removed

A. Remove existing structures indicated to be removed to grade. Interior walls, other than retaining walls and partitions, shall be removed to three feet below grade or to top of concrete slab on ground.

B. Demolish structures in a systematic manner from the top of the structure to the ground. Complete demolition work above each tier or floor before the supporting members on the lower level are disturbed. Demolish concrete and masonry walls in small sections. Remove structural framing members and lower to ground by means of derricks, platforms hoists, or other suitable methods.

C. Locate demolition and deconstruction equipment throughout the structure and remove materials so as to not impose excessive loads to supporting walls, floors, or framing.

D. Remove sidewalks, curbs, and gutters as indicated.

E. Utilities and Related Equipment

1. General Requirements: Do not interrupt existing utilities serving occupied or used facilities, except when authorized in writing by the Engineer. Do not begin demolition work until all utility disconnections have been made. Shut off and cap utilities for future use, as indicated.

2. Disconnecting Existing Utilities: Remove existing utilities, uncovered by work and terminate in a manner conforming to the nationally recognized code covering the specific utility and approved by the Engineer. When utility lines are encountered but are not indicated on the drawings, notify the Engineer prior to further work in that area. Remove meters and related equipment and deliver to Owner in accordance with instructions of the Engineer.

F. Paving and Slabs

1. Remove sawcut concrete and asphaltic concrete paving and slabs as indicated. Provide neat sawcuts at limits of pavement removal.

G. Concrete

1. Saw concrete along straight lines to a depth of a minimum 2 inch. Make each cut in walls perpendicular to the face and in alignment with the cut in the opposite face. Break out the remainder of the concrete provided that the broken area is concealed in the finished work, and the remaining concrete is sound. At locations where the broken face cannot be concealed, grind smooth or saw cut entirely through the concrete.

H. Patching

1. Where removals leave holes and damaged surfaces exposed in the finished work, patch and repair these holes and damaged surfaces to match adjacent finished surfaces, using on-site materials when available. Where new work is to be applied to existing surfaces, perform removals and patching in a manner to produce surfaces suitable for receiving new work. Finished surfaces of patched area shall be flush with the adjacent existing surface and shall match the existing adjacent surface as closely as possible as to texture and finish. For concrete and masonry, completely fill holes and depressions, left as a result of removals in existing masonry walls to remain, with an approved masonry patching material, applied in accordance with the manufacturer's printed instructions.

I. Mechanical Equipment and Fixtures

1. Disconnect mechanical hardware at the nearest connection to existing services to remain, unless otherwise noted. Disconnect mechanical equipment and fixtures at fittings. Remove service valves attached to the unit.

2. Do not remove equipment until approved.

3. Tanks, piping and fixtures shall be drained; interiors, if previously used to store flammable, explosive, or other dangerous liquids, shall be purged and hazardous material shall be disposed of per applicable law. Seal openings with caps, plates, or plugs.

J. Piping: Disconnect piping at unions, flanges and valves, and fittings. Carefully dismantle piping that previously contained gas, gasoline, oil, or chlorine gas or solution, with precautions taken to prevent injury to persons and property.

K. Electrical Equipment and Fixtures

1. Disconnect primary, secondary, control, communication, and signal circuits at the point of attachment to their distribution system.

2. Electrical Devices: Remove switches, switchgear, transformers, conductors including wire and nonmetallic sheathed and flexible armored cable, regulators, meters, instruments, plates, circuit breakers, panelboards, outlet boxes, and similar items.

3. Wiring Ducts or Troughs: Remove wiring ducts or troughs.

4. Conduit and Miscellaneous Items: Remove conduit except where embedded in concrete or masonry.

3.2 Disposition of Material

A. Title to Materials: All non-salvageable materials and equipment shall become the property of the Contractor and shall be removed from Owner's property. Title to non-salvageable materials resulting from demolition, and non-salvageable materials and equipment to be removed, is vested in the Contractor, unless otherwise indicated by the Owner.

3.3 Cleanup

A. Remove debris and rubbish. Remove and transport the debris in a manner that prevents spillage on streets or adjacent areas. Apply local regulations regarding hauling and disposal.

3.4 Disposal of Removed Materials

A. Regulation of Removed Materials: Dispose of debris, rubbish, scrap, and other non-salvageable materials resulting from removal operations in accordance with all applicable federal, state and local regulations.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Resurfacing of concrete surfaces in preparation for finish materials.

2. Non-structural crack repair of small cracks.

B. Related sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

2. It is the Contractor’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.

1.2 Definitions

A. Surface Repair Areas: Areas that are deemed to be defective excluding large cracks.

B. Defective Areas: Surface defects that include honeycomb, rock pockets, and indentations greater than 3/16”; cracks 0.010” wide and larger, as well as any crack that leaks, for hydraulic structures and below grade habitable spaces; cracks 0.015” wide and larger in non-hydraulic structures; spalls; chips; air bubbles greater than ¾” in diameter; pinholes; bug holes; embedded debris; fins and other projections; form pop-outs; texture irregularities; and stains that cannot be removed by cleaning.

C. Large Cracks: Wider than 0.015”.

D. Small Cracks: Width greater than or equal to 0.010” and less than or equal to 0.015”, as well as any smaller cracks that leak.

1.3 Submittal

A. Information Submittals:

1. Manufacturer’s product date and installation bulletin.

2. Written description of equipment proposed for surface preparation.

3. Certificates:

    a. Certificate of Compliance that proposed product systems meet or exceed specified performance criteria when tested in accordance with Article FIELD QUALITY CONTROL.

    b. Mortar system Manufacturer’s Certificate of Proper Installation.

4. Statements of Qualification:

    a. Independent testing laboratory.

    b. Mortar system Manufacturer’s Representative.

5. Mortar system Manufacturer’s proposed modified test procedures for ASTM C 109 and ASTM C 882 test methods.

6. Independent testing laboratory test report.

1.4 Quality Assurance

A. Qualifications:

1. Independent Testing Laboratory: Based on evaluation of laboratory submitted criteria in accordance with ASTM E 699.

2. Mortar System Applicator: For low pressure spray mortar system in lieu of endorsement, complete mortar system manufacturer’s demonstration in accordance with Article MANUFACTURER’S SERVICES.

Part 2 Products

2.1 Low Pressure Spray Mortar System (For Vertical And Overhead)

A. Mortar: One component, rheoplastic, cement-based, fiber reinforced, shrinkage compensated, gray in color, with a minimum 30-minute working time.

1. Sprayable, extremely low permeability, sulfate resistant, easy to use and requiring only the addition of water.

2. Free of chlorides and other chemicals causing corrosion.

B. Manufacturer and Product equal to:

1. Master Builders Technologies Co., MasterEmaco S 488CI with Concresive liquid (LPL) bonding agent for hand applied areas.

2. Sika Corp., SikaRepair 224.

2.2 Polymer-Modified Repair Mortar (Horizontal Surface Repair)

A. Mortar: One component, polymer-modified, cementitious based, chloride resistant, flowable, gray in color, working time of 20 minutes minimum, surface renovation mortar.

1. Hand applied, extremely low permeability, sulfate resistant, easy to use and requiring only the addition of water.

2. Free of chlorides and other chemicals causing corrosion.

B. Manufacturers and Products equal to:

1. Master Builders Technologies Co., MasterEmaco T 310CI

2. Sika Corp., SikaRepair 222

2.3 Water

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

2.4 Accessories

A. Finishing Aid Manufacturer and Product equal to: Master Builders Inc., Cleveland, OH; CONFILM.

B. Flexible Cementitious Rebar Coating Manufacturer and Product equal to: Master Builders Inc., Cleveland, OH; EMACO P22.

Part 3 Execution

3.1 General

A. Repair small cracks and surface defects as outlined by this specification.

3.2 Preparation

A. Remove unsound and deteriorated concrete from Work by high pressure water blasting.

B. Collect and dispose of water from removal operations in manner and location acceptable to Owner.

C. Do not use power-driven jackhammers and chipping hammers, unless water blasting is prohibited due to potential damage to installed equipment.

D. Remove concrete minimum of 1” clearance around rebar for application and bonding of new mortar to entire periphery of exposed rebar if the following surface conditions exist:

1. 50% or more of periphery around rebar is exposed during removal of concrete.

2. 25% or more of periphery around rebar is exposed during removal of concrete and corrosion has eventuated to the extent that loss of section has occurred.

3. Bond between existing concrete and reinforcement has deteriorated.

E. Clean exposed reinforcing bars of rust and concrete, and coat with flexible cementitious rebar coating.

F. Maintain surface areas free of slurry where concrete has been removed. Remove slurry from prepared areas before new mortar is applied.

G. Clean surface areas to be filled with new mortar of laitance and contamination by high pressure water blasting not more than 24 hours before applying bonding agent, Saturated Surface Dry (SSD) existing concrete at time of application of mortar.

3.3 Low Pressure Spray Mortar Application

A. Apply mortar according to manufacturer’s written instructions.

B. Finish mortar with a hand float application to smooth even surface matching adjacent concrete. Provide finishing aid at full strength.

C. Bonding Agent:

1. Hand apply bonding agent within 20 minutes of troweling on mortar. Prevent bonding agent from drying by reapplying bonding agent to maintain surface tackiness of coat.

2. Work mortar firmly and quickly into area and compact with firm trowel stroke. Finish smooth with finishing aid at full strength.

3.4 Polymer-Modified Repair Mortar Application For Repair Of Horizontal Surfaces

A. Hand Troweling: Apply according to manufacturer’s written instructions.

B. Work material firmly into the side and bottom of patch to assure a good bond. Level repair mortar and screed to elevation of existing concrete.

C. Finish to same texture as existing concrete around patch.

D. Use self-leveling mixture where appropriate to obtain uniform or plane surface.

E. Use Manufacturer’s standard bonding agent for applications of old to new concrete and as otherwise recommended by manufacturer.

3.5 Curing

A. Water fog nozzle all of the mortar systems prior to curing in accordance with mortar system Manufacturer’s instructions.

B. Commence water curing after mortar system application and when curing will not cause erosion of mortar.

C. Continuously cure mortar system for a period of 7 days.

D. Do not cure membrane, unless method is part of mortar system Manufacturer’s instructions and approval has been obtained.

3.6 Field Quality Control

A. Independent testing laboratory shall perform the following:

1. Obtain actual core samples from the completed repair Work and test, if periodic testing is required by the Owner or as required by Engineer.

2. Perform “modified” ASTM C 109 and ASTM C 882 test methods in accordance with manufacturer’s approved modifications of testing procedures.

B. Construction Testing:

1. Production Samples:

    a. Obtain mixed mortar material from shotcrete or spray equipment and produce samples, and cure samples prior to testing.

    b. Provide minimum of three samples each test for each 1,000 square feet or portion thereof of mortar repair to be installed.

2. Core Samples of In-Place Repair:

    a. Obtain two core samples and test samples for each 2,000 square feet or portion thereof for actual repair Work:

    b. Cores shall be either 2-1/2” or 3” in diameter and shall be cored through cured mortar repair and into base concrete to total depth equal to at least 2.5 times repair mortar thickness.

    c. Sawcut the cores after removal to trim base concrete thickness to same thickness as mortar so that bond line is at center of repaired sample.

    d. Samples shall be epoxy bonded to steel plates at each end using a bonding agent to prevent failure in bond to steel plates.

e. Sustain bond line without failure or movement with a minimum of 300 psi in direct tension. The tension test shall use eyebolts or threaded connectors tapped and threaded into base plate so that tension load is concentric with center of core sample.

C. Repair and fill holes where core samples have been removed using same mortar used in repair.

3.7 Manufacturer’s Services

A. Provide mortar system manufacturer’s representative at site for installation assistance, inspection and certification of proper installation, and training of mortar system applicators.

3.8 Protection

A. Protect adjacent surfaces, and equipment, from being damaged by overshooting of low pressure spray mortar.

3.9 Cleaning

A. Remove overshot mortar and deposited rebound materials as Work proceeds. Remove from Work, waste materials, unsound material from concrete surfaces, material chipped from walls, water used in preparation of application and finishing.

END OF SECTION

Part 1 General

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 Summary

A. Section Includes: Rehabilitation and repair of existing structure(s) as directed by the engineer.

1. Removal of deteriorated concrete and subsequent replacement and patching.

2. Structural reinforcement.

3. Expansion Joint repair.

1.3 Unit Price

A. Work of this Section is affected by unit prices specified in Item 4 of the Bid Form 00 30 00.

1. Unit prices apply to authorized work covered by estimated quantities.

2. Unit prices apply to authorized additions to and deletions from the Work as authorized by Change Orders.

B. General: Unit prices include the cost of preparing existing construction to receive the work indicated and costs of field quality control required for units of work completed.

1.4 Pre-Installation Meetings

A. Pre-installation Conference: Conduct conference at Project site.

1. Review methods and procedures related to concrete maintenance including, but not limited to, the following:

a. Verify concrete-maintenance specialist's personnel, equipment, and facilities needed to make progress and avoid delays.

b. Materials, material application, sequencing, tolerances, and required clearances.

c. Quality-control program.

d. Coordination with Owner and Engineer.

1) Owner to drain basins for access to structures.

2) Engineer to inspect conditions and determine applicable repair types.

1.5 Action Submittals

A. Product Data: For each type of product.

1. Include construction details, material descriptions, chemical composition, physical properties, test data, and mixing, preparation, and application instructions.

1.6 Informational Submittals

A. Qualification Data: For concrete-maintenance specialist and manufacturers.

B. Material Certificates: For each type of cement and aggregate supplied for mixing or adding to products at Project site.

C. Product Test Reports: For each manufactured bonding agent, cementitious patching mortar, joint-filler, crack-injection adhesive, polymer overlay, polymer sealer, and composite structural reinforcement, for tests performed by manufacturer and witnessed by a qualified testing agency.

D. Field quality-control reports.

E. Quality-Control Program: Submit before work begins.

1.7 Quality Assurance

A. Manufacturer Qualifications: Each manufacturer shall employ factory-authorized service representatives who are available for consultation and Project-site inspection and on-site assistance.

B. Concrete-Maintenance Specialist Qualifications: Engage an experienced concrete-maintenance firm that employs installers and supervisors who are trained and approved by manufacturer to perform work of this Section. Firm shall have completed work similar in material, design, and extent to that indicated for this Project with a record of successful in-service performance. Experience in only installing or patching new concrete is insufficient experience for concrete-maintenance work.

1. Field Supervision: Concrete-maintenance specialist firm shall maintain experienced full-time supervisors on Project site during times that concrete-maintenance work is in progress.

C. Quality-Control Program: Prepare a written plan for concrete maintenance to systematically demonstrate the ability of personnel to properly perform maintenance work, including each phase or process, protection of surrounding materials during operations, and control of debris and runoff during the Work. Describe in detail materials, methods, equipment, and sequence of operations to be used for each phase of the Work.

1.8 Delivery, Storage, And Handling

A. Comply with manufacturer's written instructions for minimum and maximum temperature requirements and other conditions for storage.

B. Store cementitious materials off the ground, under cover, and in a dry location.

C. Store aggregates covered and in a dry location; maintain grading and other required characteristics and prevent contamination.

1.9 Field Conditions

A. General: All products shall be installed according to manufacturer’s instructions. Consult product manufacturer for environmental limitations.

B. Cold-Weather Requirements for Cementitious Materials: Do not apply unless concrete-surface and air temperatures are above 40 deg F (5 deg C) and will remain so for at least 48 hours after completion of Work.

1. If mean daily air temperature falls below 40 deg F (5 deg C), cover completed Work with weather-resistant insulating blankets for 48 hours after repair or provide enclosure and heat to maintain temperatures above 40 deg F (5 deg C) within the enclosure for 48 hours after repair.

C. Hot-Weather Requirements for Cementitious Materials: Protect repair work when temperature and humidity conditions produce excessive evaporation of water from patching materials. Provide artificial shade and wind breaks, and use cooled materials as required. Do not apply to substrates with temperatures of 90 deg F (32 deg C) and above.

Part 2 Products

2.1 Manufacturers Equal To:

A. Source Limitations: For repair products, obtain each color, grade, finish, type, and variety of product from single source and from single manufacturer with resources to provide products of consistent quality in appearance and physical properties.

2.2 Bonding Agents

A. Epoxy-Modified, Cementitious Bonding and Anticorrosion Agent: Manufactured product that consists of water-insensitive epoxy adhesive, portland cement, and

B. water-based solution of corrosion-inhibiting chemicals that forms a protective film on steel reinforcement.

1. BASF Corporation; MasterEmaco P 124.

2. Euclid Chemical Co; Duralprep A.C.

3. Sika Corporation; Armatec 110 EpoCem.

2.3 Patching Mortar

A. Refer to Section 03 01 00 - Concrete Surface Repair Systems.

2.4 Structural Reinforcement Materials

A. Refer to Section 03 20 00 - Concrete Reinforcement.

2.5 Miscellaneous Materials

A. Portland Cement: ASTM C 150/C 150M, Type I/II.

B. Water: Potable.

2.6 Mixes

A. General: Mix products, in clean containers, according to manufacturer's written instructions.

1. Do not add water, thinners, or additives unless recommended by manufacturer.

2. When practical, use manufacturer's premeasured packages to ensure that materials are mixed in proper proportions. When premeasured packages are not used, measure ingredients using graduated measuring containers; do not estimate quantities or use shovel or trowel as unit of measure.

3. Do not mix more materials than can be used within time limits recommended by manufacturer. Discard materials that have begun to set.

B. Dry-Pack Mortar: Mix required type(s) of patching-mortar dry ingredients with just enough liquid to form damp cohesive mixture that can be squeezed by hand into a ball but is not plastic.

C. Concrete: Comply with Section 03 30 00 - Cast-in-Place Concrete.

Part 3 Execution

3.1 Concrete Maintenance

A. Have concrete-maintenance work performed only by qualified concrete-maintenance specialist with at least 2-years’ experience using the product(s) being installed and a history with projects of similar size and quantities.

B. Comply with manufacturers' written instructions for surface preparation and product application.

3.2 Examination

A. Notify Engineer seven days in advance of date when areas of deteriorated or delaminated concrete and deteriorated reinforcing bars will be cleaned for inspection.

1. Contractor shall use high-pressure water blasting to remove any debris, foreign material, or loose concrete from the designated areas to be inspected.

2. Upon completion of the surface cleaning, the Engineer and Contractor shall inspect the designated areas to determine the type and quantity of the repairs.

B. Perform surveys as the Work progresses to detect hazards resulting from concrete-maintenance work.

3.3 Preparation

A. Ensure that supervisory personnel are on-site and on duty when concrete maintenance work begins and during its progress.

B. Protect persons, motor vehicles, surrounding surfaces of building being repaired, building site, plants, and surrounding buildings from harm resulting from concrete maintenance work.

1. Comply with each product manufacturer's written instructions for protections and precautions. Protect against adverse effects of products and procedures on people and adjacent materials, components, and vegetation.

2. Use only proven protection methods appropriate to each area and surface being protected.

3. Provide temporary barricades, barriers, and directional signage to exclude public from areas where concrete maintenance work is being performed.

4. Erect temporary protective covers over walkways and at points of pedestrian and vehicular entrance and exit that must remain in service during course of concrete maintenance work.

5. Contain dust and debris generated by concrete maintenance work and prevent it from reaching the public or adjacent surfaces.

6. Use water-mist sprinkling and other wet methods to control dust only with adequate, approved procedures and equipment that ensure that such water will not create a hazard or adversely affect other building areas or materials.

7. Protect floors and other surfaces along haul routes from damage, wear, and staining.

8. Protect adjacent surfaces and equipment by covering them with heavy polyethylene film and waterproof masking tape. If practical, remove items, store, and reinstall after potentially damaging operations are complete.

9. Neutralize and collect alkaline and acid wastes for disposal off Owner's property.

10. Dispose of debris and runoff from operations by legal means and in a manner which prevents soil erosion, undermining of paving and foundations, damage to landscaping, and water penetration into building interiors.

C. Existing Drains: Prior to the start of work in an area, test drainage system to ensure that it is functioning properly. Notify Engineer immediately of inadequate drainage or blockage. Do not begin work in an area until the drainage system is in working order.

1. Prevent solids such as aggregate or mortar residue from entering the drainage system. Clean out drains and drain lines that become sluggish or blocked by sand or other materials resulting from concrete maintenance work.

D. Preparation for Concrete Removal: Examine construction to be repaired to determine best methods to safely and effectively perform concrete maintenance work. Examine adjacent work to determine what protective measures will be necessary. Make explorations, probes, and inquiries as necessary to determine condition of construction to be removed in the course of repair.

1. Verify that affected utilities have been disconnected and capped.

2. Inventory and record the condition of items to be removed for reinstallation or salvage.

E. Reinforcing-Bar Preparation: Remove rust from exposed reinforcing bars by high-pressure water cleaning, abrasive blast cleaning, or wire brushing.

1. Where section loss of reinforcing bar is more than 25 percent, or 20 percent in two or more adjacent bars, cut bars and remove and replace.

2. Remove additional concrete as necessary to provide at least 1-1/2-inch clear cover at existing and replacement bars.

3. Splice replacement bars to existing bars according to ACI 318 by lapping, welding, or using mechanical couplings.

F. Surface Preparation for Structural Reinforcement: Clean concrete where reinforcement and epoxy patching mortar is to be placed by low-pressure water cleaning to remove dirt, oils, films, and other materials detrimental to epoxy patching mortar.

1. Roughen surface of concrete by sand blasting.

2. Remove delaminated material and deteriorated concrete surface material around the full circumference of the reinforcing a minimum of ¾”. Concrete removal shall extend along the reinforcing until sound reinforcing is exposed.

3. Sweep and vacuum roughened surface to remove debris.

3.4 Concrete Removal

A. Do not overload structural elements with debris.

B. Remove deteriorated and delaminated concrete by breaking up and dislodging from reinforcement.

C. Remove additional concrete if necessary to provide a depth of removal of at least 1/2 inch over entire removal area.

D. Where half or more of the perimeter of reinforcing bar is exposed, bond between reinforcing bar and surrounding concrete is broken, or reinforcing bar is corroded, remove concrete from entire perimeter of bar and to provide at least 3/4-inch clearance around bar.

E. Test areas where concrete has been removed by tapping with hammer and remove additional concrete until unsound and disbonded concrete is completely removed.

F. Thoroughly clean removal areas of loose concrete, dust, and debris.

3.5 Bonding Agent Application

A. Epoxy-Modified, Cementitious Bonding and Anticorrosion Agent: Apply to reinforcing bars and concrete by stiff brush or hopper spray according to manufacturer's written instructions.

B. Apply to reinforcing bars in two coats, allowing first coat to dry two to three hours before applying second coat. Allow to dry before placing patching mortar or concrete.

3.6 Patching Mortar Application

A. Refer to Section 03 01 00 - Concrete Surface Repair.

3.7 Dry-Pack-Mortar Application

A. Use dry-pack mortar for deep cavities. Place as specified in this article unless otherwise recommended in writing by manufacturer.

1. Provide forms where necessary to confine patch to required shape.

2. Wet substrate and forms thoroughly and then remove standing water.

B. Pretreatment: Apply specified bonding agent.

C. Place dry-pack mortar into cavity by hand, and compact tightly into place. Do not place more material at a time than can be properly compacted. Continue placing and compacting until patch is approximately level with surrounding surface.

D. After cavity is filled and patch is compacted, trowel surface to match profile and finish of surrounding concrete. A thin coat of patching mortar may be troweled into the surface of patch to help obtain required finish.

E. Wet-cure patch for not less than seven days by water-fog spray or water-saturated absorptive cover.

3.8 Concrete Placement

A. Place concrete according to Section 03 30 00 - Cast-in-Place Concrete and as specified in this article.

B. Pretreatment: Apply epoxy-modified, cementitious bonding and anticorrosion agent to reinforcement and concrete substrate.

C. Fill placement cavities with dry-pack mortar and repair voids with patching mortar. Finish to match surrounding concrete.

3.9 Structural Reinforcement Application

A. Refer to Section 03 20 00 - Concrete Reinforcement.

3.10 Expansion Joint Repair

A. Clean out existing joint materials and prepare joint in accordance with manufacturer's instructions (existing waterstop to remain, if present).

B. Fill joint to ¼ depth of joint with hydrophilic grout.

C. Wet joint and allow to expand.

D. Install backer rod, and seal with urethane joint sealant.

1. In potable water structures, urethane joint sealant shall be NSF/ANSI 61-5 certified (for contact with drinking water).

3.11 Field Quality Control

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

B. Perform the following tests and inspections:

1. Packaged, Cementitious Patching Mortar: Four randomly selected sets of samples for each type of mortar required, tested according to ASTM C 928/C 928M.

2. Concrete: As specified in Section 03 30 00 - Cast-in-Place Concrete.

C. Product will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Manufacturers Field Service: Engage manufacturers' factory-authorized service representatives for consultation and Project-site inspection and to provide on-site assistance when requested by Engineer.

1. Have manufacturers' factory-authorized service representatives perform the following number of Project-site inspections to observe progress and quality of the Work, distributed over the period of product installation, regardless of on-site assistance requested by Engineer:

a. Bonding-Agent and Packaged Patching-Mortar Installation: Three inspections.

b. Joint-Filler Installation: Two inspections.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Concrete formwork.

B. Related sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.2 References

A. Comply with the provisions of the following codes, specifications, and standards, except where more stringent requirements are shown or specified:

B. American Concrete Institute (ACI):

1. 117, Standard Specifications for Tolerances for Concrete Construction and Materials.

2. 318/318R, Building Code Requirements for Reinforced Concrete.

3. 347, Formwork for Concrete.

4. 350, Code Requirements for Environmental Concrete

1.3 Design Requirements

A. [1]When high range water reducer (superplasticizer) is used in concrete mix, forms shall be designed for full hydrostatic pressure per ACI 347.

B. Make joints in forms tight enough to prevent loss of concrete mortar.

C. Limit panel deflection to 1/360th of each component span to achieve tolerances specified.

1.4 Submittals

A. Shop Drawings:

1. Form Ties-Tapered Through-Bolts: Proposed method of sealing form tie hole; coordinate with details shown.

2. All formwork erection, shoring and removal are the responsibility of the Contractor and/or the qualified professional engineer the contractor used for the formwork drawings.

3. Indicate proposed schedule and sequence of stripping formwork, shoring removal, and installing and removing re-shoring.

4. Manufacturer’s Data for the Following Product: Form release agent.

5. Formwork drawings shall be signed and sealed by the professional engineer licensed in the state of the work and responsible for their preparation.

B. Samples: One each as follows:

1. Form ties.

1.5 Qualifications

A. Formwork Designer: Formwork, falsework, and shoring design shall be by a Qualified Professional Engineer licensed in the state of the work.

Part 2 Products

2.1 Form Materials

A. Wall Forms and Underside of Slabs:

1. Materials: Plywood, hard plastic finished plywood, overlaid waterproof particle board, or steel in “new and undamaged” condition, of sufficient strength and surface smoothness to produce specified finish.

2. Circular Structures:

   a. Conform forms to circular shape of structure.

   b. Straight panels may be substituted for circular forms provided panels do not exceed 2’ in horizontal width and angular deflection is no greater than 3-1/2° per joint.

B. Painted Surface Forms: High density overlay plywood for flat concrete surfaces to be painted.

C. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints. Furnish on exposed surfaces and interior surfaces.

D. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit. Permitted to furnish on below grade exterior surfaces

E. Forms for Cylindrical Columns, Pedestals, and Supports: Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.

F. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.

G. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.

H. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch, minimum.

I. Form Release Agent:

1. Material: Release agent shall not bond with, stain, or adversely affect concrete surfaces, and shall not impair subsequent treatments of concrete surfaces when applied to forms. A “ready-to-use” water-based material formulated to reduce or eliminate surface imperfections, containing no mineral oil or organic solvents. Environmentally safe, meeting local, state, and federal regulations and can be used in potable water facilities.

2. Manufacturers and Products:

a. Master Builders, Inc.; Rheofinish 211.

b. Cresset Chemical Company; Crete-Lease 20-VOC.

c. US Mix Products Company; US SPEC Slickote.

d. Or approved equal.

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

K. Form Ties:

1. Material: Steel

2. Spreader Inserts:

a. Conical or spherical type.

b. Design to maintain positive contact with forming material.

c. Furnish units that will leave no metal closer than 1” to concrete surface when forms, inserts, and tie ends are removed.

3. Wire ties not permitted.

4. Flat bar ties for panel forms furnish plastic or rubber inserts with minimum 1” depth and sufficient dimensions to permit patching of tie hole.

5. Water Stop Ties: For water-holding structures, basements, pipe galleries, and accessible spaces below finish grade, furnish one of the following:

   a. Integral steel water stop 0.103” thick and 0.625” in diameter tightly and continuously welded to tie.

   b. Neoprene water stop 3/16” thick and 15/16” diameter whose center hole is 1/2-diameter of tie, or molded plastic water stop of comparable size.

   c. Orient water stop perpendicular to tie and symmetrical about center of tie.

   d. Design ties to prevent rotation or disturbance of center portion of tie during removal of ends and to prevent water leaking along tie.

6. Through-Bolts: Tapered minimum 1” diameter at smallest end.

7. Elastic Vinyl Plug:

   a. Design and size of plug to allow insertion with tool to enable plug to elongate and return to original length and diameter upon removal forming watertight seal.

   b. Manufacturer and Product: Dayton/Richmond Co., Miamisburg, OH; A58 Sure Plug, or approved equal.

   c. Recess plug 1” minimum and grout over hole. See Section 03 60 00 - Grout.

Part 3 Execution

3.1 Form Surface Preparation

A. Thoroughly clean form surfaces that will be in contact with concrete or that have been in contact with previously cast concrete, dirt, and other surface contaminants prior to coating surface.

B. Exposed Wood Forms in Contact with Concrete: Apply form release agent as recommended by the manufacturer.

C. Steel Forms: Apply form release agent to steel forms as soon as they are cleaned to prevent discoloration of concrete from rust.

3.2 Erection

A. General: Unless specified otherwise, follow applicable recommendations of ACI 347.

B. Beveled Edges (Chamfer):

1. Form 3/4” bevels (chamfers) at all exposed concrete edges, unless otherwise shown.

C. Wall Forms

1. Do not reuse forms with damaged surfaces.

2. Locate form ties and joints in an uninterrupted uniform pattern.

3. Inspect form surfaces prior to installation to assure conformance with specified tolerances.

D. Forms for Curbs and Sidewalks

1. Provide standard steel or wood forms.

2. Set forms to true lines and grades, and securely stake in position.

E. Form Tolerances: Provide forms in accordance with ACI 117, 347 and 318 and the following tolerances for finishes specified:

1. Wall Tolerances:

a. Straight Vertical or Horizontal Wall Surface: Flat planes within tolerance specified.

b. Wall Type W-A:

1) Plumb within 1/4” in 10’ or within 1” from top to bottom for walls over 40 feet high.

2) Depressions in Wall Surface: Maximum 5/16” when 10’ straightedge is placed on high points in all directions.

c. Wall Type W-B:

1) Plumb within 1/8” in 10’ or within 1/2” from top to bottom for walls over 40’ high.

2) Depressions in Wall Surface: Maximum 1/8” when 10’ straightedge is placed on high points in all directions.

2. Thickness: Maximum -1/4” or +1/2” from dimension shown.

3. Form Offset: Between adjacent pieces of form work, facing material shall not exceed 1/8” where exposed to public view and 1/4” maximum for all other conditions.

3.3 Additional Requirements

A. Construct forms tight enough to prevent loss of concrete mortar.

B. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.

1. Install keyways, reglets, recesses and the like for easy removal.

2. Do not use rust-stained steel form-facing material.

3. Use only form or form-tying methods which do not cause spalling of the concrete upon form stripping or tie removal.

C. Set edge forms, bulkheads and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

D. Provide temporary 12 inch wide x 18 inch high openings for cleanouts and inspection ports every 7 feet at the bottom of each lift form and where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations, where possible.

E. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds and bulkheads required in the Work.

1. Determine sizes and locations from trades providing such items.

2. Openings shall be of sufficient size to permit final alignment of pipes or other items without deflection or offsets of any kind. Allow space for packing where items pass through the wall to ensure watertightness. Provide openings with continuous keyways and waterstops. Provide a slight flare to facilitate grouting and the escape of entrained air during grouting. Provide formed openings with reinforcement as indicated in the typical structural details. Reinforcing shall be at least 2 inches clear from the opening surfaces and encased items.

F. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt and other debris just before placing concrete.

G. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

H. Coat contact surfaces of forms with form-release agent, according to manufacturer’s written instructions before placing reinforcement.

I. Embedded Items.

1. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions and directions furnished with items to be embedded.

    a. Install anchor bolts/rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC’s “Code of Standard Practice for Steel Buildings and Bridges.”

    b. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles and other conditions.

    c. Check special castings, channels or other metal parts that are to be embedded in the concrete prior to and again after placing the concrete.

    d. Check nailing blocks, plugs and strips necessary for the attachment of trim, finish and similar work prior to placing the concrete.

J. Pipes and wall spools cast in concrete.

1. Install wall spools, wall flanges, and wall anchors before placing concrete. Do not weld, tie or otherwise connect the wall spools or anchors to the reinforcing steel.

2. Support pipe and fabricated fittings to be encased in concrete on concrete piers or pedestals. Carry concrete supports to firm foundations so that no settlement will occur during construction.

3. Pipes or spools located below operating water level shall have waterstop ring collars and shall be cast in place. Do not block out such piping and grout after the concrete section is cast. Pipes fitted with thrust rings shall be cast in place.

K. Removing and reusing forms.

1. General: Do not remove forms from concrete which has been placed with outside temperature below 50°F without first determining and verifying with Engineer if the concrete has properly set without regard for time. Do not apply loading on green concrete. Immediately after forms are removed, the surface of the concrete shall be carefully examined and any irregularities in the surface shall be repaired and finished as specified.

    a. Leave formwork for structural slabs, beams and other structural elements that support weight of concrete in place until concrete has achieved 100% of its design compressive strength and a minimum of 14 days.

b. Formwork for sides of beams, walls, columns and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50°F for 48 hours after placing concrete, if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.

c. For structures with a structural roof slab, leave bracing for walls until the roof slab concrete reaches 100% of its design compressive strength and a minimum of 14 days.

d. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

2. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.

3. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved in writing by the Engineer.

L. Aluminum surfaces in contact with concrete.

1. Aluminum surfaces in contact with concrete or grout or dissimilar metals shall be protected with a Mylar isolator, bituminous paint or other material approved by Engineer.

M. Shores and reshores.

1. Comply with ACI 318 (ACI 318M) and ACI 301 for design, installation and removal of shoring and reshoring.

a. Do not remove shoring or reshoring until measurement of slab tolerances is complete.

2. In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members without sufficient steel reinforcement.

3. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

END OF SECTION

Part 1 General

1.1 Summary

A. Section includes:

1. Waterstops.

2. Joint Fillers.

3. Vapor Barriers.

4. Floor Slab Treatments.

1.2 References

A. ASTM International (ASTM):

1. ASTM D570 - Standard Test Method for Water Absorption of Plastics.

2. ASTM D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.

3. ASTM D638 - Standard Test Method for Tensile Properties of Plastics.

4. ASTM D747 - Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.

5. ASTM D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

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

B. U. S. Army Corps of Engineers (USACE):

1. CRD-C-572, Specification for Polyvinyl Chloride (PVC) Waterstop.

1.3 Submittals

A. Product Data: Provide sufficient information on each type of material for review to determine conformance of material to requirements specified.

1. Waterstops: Complete physical characteristics.

2. Preformed expansion joint material.

B. Laboratory test reports: Indicating that average properties of waterstop materials and finish conform to requirements specified in this Section.

C. Certificates of Compliance:

1. Written certificates that polyvinyl chloride waterstops supplied on this Project meet or exceed physical property in accordance with USACE CRD-C-572 and the requirements of this Section.

D. Manufacturer's instructions: For materials specified in this Section that are specified to be installed with such instructions.

1.4 Quality Assurance

A. Materials:

1. PVC waterstops: Shall be free of misalignment, bubbles, inadequate bond, porosity, cracks, offsets, and other defects which would reduce the potential resistance of the material to water pressure at any point. Replace faulty material.

B. Inspections:

1. Waterstop: For installation according to manufacturer’s recommendations.

2. Vapor Barriers: For installation according to the drawings and free from tears.

3. Joint Filler: Joints shall be free of debris prior to placing joint filler.

4. Floor Slab Treatment: For installation according to manufacturer’s recommendations.

Part 2 Products

2.1 Waterstops

A. Polyvinyl Chloride (PVC) Waterstops:

1. General: Manufactured from polyvinyl chloride plastic compound containing the plasticizers, resins, stabilizers, and other materials necessary to meet the requirements of this Section. No scrap or reclaimed material shall be used.

2. Manufacturers: One of the following or approved equal:

a. Greenstreak Plastic Products Company, Inc.

b. Vinylex Corporation.

3. Type: Ribbed with Center bulb (non-tapered):

   a. Construction and Expansion joints: 6-inch long.

      1) Greenstreak Style 732.

      2) Vinylex RB638H.

   b. Construction joints: 4-inch long (where indicated).

      1) Greenstreak Style 702.

   c. Expansion joints: 9-inch long.

      1) Greenstreak Style 735.

      2) Vinylex RB938H.

4. Dumbbell type waterstop will not be allowed unless otherwise specified or indicated on the Drawings.

B. Strip-Type Waterstops:

1. General: Unless noted otherwise, strip-type waterstops shall be:

   a. Expansive type only when waterstop is placed between two layers of reinforcing.

   b. Non-Expansive type for all other conditions.

2. Expansive Strip-type Waterstops Profile: 1” x ¾”

   a. General: Manufactured from expansive butyl rubber compound. No scrap or reclaimed material shall be used.

   b. Install only at locations as shown on the drawings or as directed by the Engineer.

   c. Expansive strip-type waterstops shall be installed inside of, or between, reinforcing bars, where applicable. Maintain manufacturer’s minimum cover requirements at all times.

   d. Greenstreak Swellstop

   e. Vinylex BlueStop

3. Non-expansive Strip-type Waterstops Profile: 1” x ¾”

   a. General: Self-sealing mastic waterstop. No scrap or reclaimed material shall be used.

b. Install only at locations as shown on the drawings or as directed by the Engineer.

c. Maintain manufacturer’s minimum cover requirements at all times.

d. Greenstreak Lockstop.

e. Vinylex UltraStop.

2.2 Joint Fillers

A. Expansion and Isolation Joint Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber.

B. Semi-rigid Joint Filler: Two-component, semi-rigid, 100 percent solids, epoxy resin with a Type A shore durometer hardness of 80 per ASTM D2240.

C. Preformed expansion joint materials: No scrap or recycled material shall be used.

1. Bituminous fiber expansion joint material equal to:

a. Tamms Industries: Hornboard/fiber.

2. Synthetic sponge rubber expansion joint material equal to:

a. Tamms Industries: Cementone.

2.3 Vapor Barriers

A. Plastic Vapor Barrier: ASTM E1745, Class B. Include manufacturers’ recommended adhesive or pressure-sensitive tape. Minimum thickness: 15 mils.

B. Granular Fill: Clean mixture of crushed stone or crushed or uncrushed gravel; ASTM D448, Size 57, with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.

2.4 Floor and Slab Treatments

A. General: Clear, chemically reactive, waterborne solution of inorganic silicate or siliconate materials and proprietary components; odorless; that penetrates, hardens, and densifies concrete surfaces.

2.5 Bonding Agents

A. Bonding Agent: ASTM C1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

B. Epoxy Bonding Adhesive: ASTM C881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:

1. Types IV and V, load bearing for bonding hardened or freshly mixed concrete to hardened concrete.

Part 3 Execution

3.1 Waterstops - Installation

A. Waterstops shall be stored so as to permit free circulation of air around the waterstop material and to prevent direct exposure to sunlight.

B. Carry waterstops in walls into lower slabs and join to waterstops in slabs with appropriate types of fittings.

C. In water-bearing structures: Provide all joints with waterstops, whether indicated on the Drawings or not.

D. Hold and securely fix edges in position at intervals of not more than 24 inches so that they do not move during placing of concrete.

E. Do not drive nails, screws, or other fasteners through waterstops in vicinity of construction joints.

F. Terminate waterstops 3 inches from top of finish surfaces of walls and slabs unless otherwise shown on the Drawings.

G. Weld joints such as unions, crosses, ells, and tees, with thermostatically controlled equipment recommended by waterstop manufacturer:

1. The material shall not be damaged by heat sealing.

2. Make joints by overlapping, cut the ends of the sections to be spliced so they will form a smooth even joint. Heat the cut ends with the splicing tool until the plastic melts. Press the two ends together until the plastic cools.

3. The continuity of the waterstop ribs and tubular center axis shall be maintained.

4. The splices shall have a tensile strength of not less than 60 percent of the unspliced materials tensile strength.

H. Butt joints of the ends of two identical waterstop sections may be made while the material is in the forms.

I. Joints for crosses and tees shall be factory prefabricated by the manufacturer.

3.2 Vapor Retarders

A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder according to ASTM E1643 and manufacturer's written instructions.

B. Lap joints 6 inches or as required by the manufacturer and seal with manufacturers' recommended tape.

3.3 Joints

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

B. Preformed expansion joint material: Fasten expansion joint strips to concrete, masonry, or forms with adhesive. No nailing will be permitted, nor shall expansion joint strips be placed without fastening.

C. Construction Joints:

1. Install so strength and appearance of concrete are not impaired.

2. Provide joints only as indicated on the drawings or as approved by the Engineer.

3. All joints in hydraulic structures to have waterstops.

4. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

D. Contraction Joints in Slabs-on-Grade:

1. Form weakened-plane contraction joints, in slabs-on-grade only as indicated on the drawings.

2. No slabs for hydraulic structures shall have contraction joints, unless indicated otherwise on the drawings.

3. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.

4. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/4-inch wide joints maximum into concrete, when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

E. Isolation Joints in Slabs-on-Grade:

1. Extend joint filler strips full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated.

2. Terminate full-width joint filler strips not less than 1/2 inch or more than 1 inch below finished concrete surface where joint sealants are indicated, specified in Spec 07 92 00 Section "Sealants and Caulking".

3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

F. Doweled Joints:

1. Install dowel bars and support assemblies at joints where indicated. Lubricate or epoxy-coat one-half of dowel length to prevent concrete bonding to one side of joint.

G. Joint Filling

1. Prepare, clean, and install joint filler according to manufacturer's written instructions.

a. Defer joint filling until concrete has aged at least 90 days. Do not fill joints until construction traffic has permanently ceased.

2. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.

3. Install semi-rigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

3.4 Liquid Floor Treatments

A. Penetrating Liquid Floor Treatment:

1. Prepare, apply, and finish penetrating liquid floor treatment according to manufacturer's written instructions.

2. Do not apply to concrete that is less than 28 days old.

3. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.

4. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing. Rinse with water; remove excess material until surface is dry. Apply a second coat in a similar manner if surface is rough or porous.

B. Sealing Coat: Uniformly apply a continuous sealing coat of curing and sealing compound to hardened concrete by power spray or roller according to manufacturer's written instructions.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Reinforcing steel and related items required for cast-in-place concrete.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.2 References

A. American Concrete Institute (ACI):

1. ACI 117 - Specifications for Tolerances for Concrete Construction and Materials.

2. ACI 318 - Building Code Requirements for Structural Concrete and Commentary.

3. ACI 350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.

B. Concrete Reinforcing Steel Institute (CRSI) - Manual of Concrete Practice.

1.3 Supervision

A. Workmanship: Provide qualified supervision at all times reinforcing work is in progress. Workmen shall be experienced iron workers.

B. Codes: Reinforcement placement and detailing shall comply with practice specified in the "Manual of Standard Practice for Detailing Reinforced Concrete Structures" publication ACI 315- latest edition of the American Concrete Institute or its latest revision, unless otherwise specified herein.

1.4 Submittals

A. Shop drawings: Shop drawings shall be prepared for all reinforcement required by the project. Shop drawings shall be logically and legibly prepared to permit reasonable ease of sorting, selecting, placing reinforcement as well as checking drawings. Preparer and fabricator shall be identified on the drawings.

1. Reinforcement shall not be fabricated until the shop drawings have been processed, approved and returned.

2. Check all shop drawings to verify reinforcement dimensions required by drawings are satisfied.

3. Provide bar sizes, bar lengths, bar material, bar grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and lap lengths, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.

B. Reinforcement shop drawings:

1. Review of reinforcement shop drawings by the Engineer will be limited to general compliance with the Contract Documents.

2. Submit reinforcement shop drawings in a complete package for each specific structure. Partial submittals will be rejected.

C. Changes to reinforcing steel contract drawing requirements:

1. Indicate in separate letter submitted with shop drawings any changes of requirements indicated on the Drawings for reinforcing steel.

D. Such changes will not be acceptable unless the Engineer has accepted such changes in writing.

1.5 Product Handling

A. Protection:

1. Use all means necessary to protect reinforcement from dirt and other foreign substances before and after placing.

2. Store in a neat manner in logical order, bundled, tagged, off the ground, and in an area adequately isolated.

3. Re-bundle to maintain identification when placing is interrupted.

B. Replacement: All damaged or improperly fabricated bars shall be replaced at the Contractor's expense.

Part 2 Products

2.1 Concrete Reinforcement

A. General:

1. All reinforcement bars shall be deformed, carbon steel bars in accordance with ASTM A615 Grade 60.

2. All reinforcement shall be free from rust, loose mill scale, and other contaminants.

B. Wire bar supports located between reinforcing bars and face of concrete:

1. Stainless steel. Type 304 stainless steel bar supports.

2. Support reinforcing for concrete placed on ground using bar support chairs with Type 304 stainless steel plates for resting on ground welded to the chairs.

C. Concrete bar supports located between reinforcing bars and face of concrete:

1. Manufactured expressly for supporting reinforcing bars.

2. Manufactured with two annealed steel wires to securely tie concrete bar support to reinforcing steel.

3. Manufactured with f'_c at least 1,000 psi greater than concrete compressive strength.

2.2 Welded Wire Reinforcement (WWR)

A. General:

1. All WWR shall be carbon steel, welded wire in accordance with ASTM A1064.

2. WWR may not be used in place of reinforcing bars unless accepted in writing by the Engineer.

3. Provide WWR in flat sheet form.

2.3 Accessories

A. General: Accessories shall be subject to Engineer's approval.

B. Tie wire - 18 gauge annealed steel wire.

C. Number of chairs shall be adequate to prevent sag during steel and concrete placement.

D. Wall layer spacers shall be 1/4 inch round "Z" bar.

E. Horizontal layer spacers shall be wire bar supports or reinforcing bars bent to support top layer.

F. Dowel bar splicer shall be Richmond or approved equal, manufactured from standard specified rebar material, with NC threads and shop fabricated to specified dowel configurations.

G. Expansion Joint Dowel Bars: ASTM A615/A615M, Grade 60, plain-steel bars, cut true to length with ends square and free of burrs.

1. All dowels shall be placed and securely anchored before placing concrete. All dowels shall be parallel with each other and perpendicular to the joint.

H. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:

1. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.

2. Secure all reinforcement in place using steel chairs, supports, “A” bars and any other ACI approved product. Supports shall be spaced adequately to support the steel firmly in place.

3. Chairs will not be accepted to hold reinforcing clearance on walls.

Part 3 Execution

3.1 General

A. Coordinate all work of other trades to avoid conflict with reinforcement.

B. Contractor is responsible for checking shop drawings to verify compliance with the drawings. Prior to submitting shop drawings to the Engineer, the contractor shall confirm all bar materials, quantities, sizes, and spacings, as well as all bent bar and lap splice lengths.

3.2 Fabricating

A. General: Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice." Reinforcement shall be shop fabricated except where straight bars No. 5 or smaller are required.

B. Bending: All bending shall be by using bending jigs and mandrels. All bars shall be bent cold.

C. Cutting: Bars shall be cut by cold shearing. Torch cutting in the field may be permitted in special situations.

3.3 Preparation

A. Surface Preparation:

1. Reinforcing bars: Thin coating of red rust resulting from short exposure will not be considered objectionable. Thoroughly clean any bars having rust scale, loose mill scale, or thick rust coat.

2. Cleaning of reinforcement materials: Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent concrete placement.

3.4 Placing

A. General:

1. Accurately place all bars to meet tolerances as outlined in ACI 318 and tie in place before placing concrete, include dowels. Tie with 18 gauge steel wire.

2. Corner bars required for horizontal reinforcing.

3. No field bending of bars will be allowed.

B. Clearance:

1. Preserve clearance between bars of 1 inch minimum, not less than one bar diameter or 1-1/3 times large aggregate, whichever is larger.

2. Clear cover shall be as shown in the drawings.

3. Lap all reinforcing bars with a Class B Tension lap or as required by ACI 318.

4. Stagger splices except where otherwise shown.

5. Lap welded wire reinforcement a minimum of two spaces.

C. Supports:

1. Provide a sufficient number to prevent sagging, to prevent shifting, and to support loads during construction; but in no case less than quantities and at locations as indicated in ACI 315.

2. Do not use brick, broken concrete masonry units, spalls, rocks, wood or similar materials for supporting reinforcing steel.

3. Do not use reinforcing bars that have less cover than required by the Contract Documents. Do not adjust location of reinforcement required by the Contract Documents to provide cover to these bars.

4. Wire chairs will not be accepted to hold reinforcing clearance on walls.

D. Tying of bar reinforcement:

1. Fasten bars securely in place with wire ties.

2. Tie bars sufficiently to prevent shifting during construction or concrete placement.

3. Tie slab bars at every intersection around periphery of slab.

4. Tie wall bars at not greater than following maximum spacings:

Bar Size	**Slab Bar Spacing Inches**	**Wall Bar Spacing Inches**
Bars Number 5 and Smaller	60	48
Bars Number 6 through Number 9	96	60
Bars Number 10 and Number 11	120	96

5. After tying wire ties, bend ends of wire ties in towards the center of the concrete section.

a. The cover for wire ties shall be the same as the cover requirements for reinforcing bars.

E. Openings and obstructions:

1. Place additional reinforcing around openings as shown on the drawings and standard details.

2. Consult Engineer on special situations.

F. Welded Wire Reinforcement:

1. Install necessary supports to keep WWR in place while concrete is being placed.

2. Straighten fabric to make flat sheet before placing.

3. Splice fabric in accordance with ACI 318.

END OF SECTION

Part 1 General

1.1 Summary

A. Section includes cast-in-place concrete, including concrete materials, concrete mixture designs, placement procedures, and finishes.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

a. See Section 03 01 00 - Concrete Surface Repair Systems for concrete patching and surface repairs.

b. See Section 03 01 30 – Concrete Maintenance and Repair for deteriorated concrete repair, crack repair, exposed reinforcement repair, and expansion joint repair.

c. See Section 03 11 00 - Concrete Formwork for additional requirements.

d. See Section 03 15 00 - Concrete Accessories for related materials.

e. See Section 03 20 00 - Concrete Reinforcement for additional requirements.

f. See Section 03 64 00 - Concrete Repair Crack Injection for concrete crack repair.

1.2 References

A. Comply with the provisions of the following codes, specifications, and standards, except where more stringent requirements are shown or specified:

B. American Concrete Institute (ACI):

1. ACI 117 - Specifications for Tolerances for Concrete Construction and Materials.

2. ACI 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.

3. ACI 301 - Specifications for Structural Concrete.

4. ACI 302.1R - Guide for Concrete Floor and Slab Construction.

5. ACI 304 - Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete.

6. ACI 305 - Hot Weather Concreting Standard.

7. ACI 306 - Cold Weather Concreting Standard.

8. ACI 308.1 - Standard Specification for Curing Concrete.

9. ACI 318 - Building Code Requirements for Structural Concrete and Commentary.

10. ACI 350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.

C. ASTM International (ASTM):

1. ASTM C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.

2. ASTM C33 - Standard Specification for Concrete Aggregates.

3. ASTM C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

4. ASTM C42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

5. ASTM C94 - Standard Specification for Ready-Mixed Concrete.

6. ASTM C150 - Standard Specification for Portland Cement.

7. ASTM C172 - Standard Practice for Sampling Freshly Mixed Concrete.

8. ASTM C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.

9. ASTM C192 - Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.

10. ASTM C231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

11. ASTM C494 - Standard Specification for Chemical Admixtures for Concrete.

12. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

13. ASTM C1064 - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.

14. ASTM C1077 - Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation.

15. ASTM C1116 - Standard Specification for Fiber-Reinforced Concrete.

1.3 Definitions

A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.

B. Exposed Concrete: Concrete surface that can be seen inside or outside of structures regardless whether concrete is above water, dry at all times, or can be seen when structure is drained.

C. Hydraulic Structures: Liquid containing basins including, but not limited to: clarifiers, aerations basins, digesters, wet wells, hydraulic channels, pipe trenches, sumps.

1.4 Submittals

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

B. Concrete Mixture Designs: For each concrete mixture.

1. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

2. Indicate amounts of mixing water to be withheld for later addition at Project site.

3. Concrete Mixture Compressive Strength.

a. Testing shall be in accordance with ACI 350.

b. Testing results shall be from tests conducted within the 12-month period prior to this submittal.

c. Provide one copy of 30 consecutive strength test results, for each mix design used, from a record of past performance.

d. Or one copy of the project specific laboratory trial mix design and testing results, for each concrete mix used in this project.

C. Welding certificates.

D. Qualification Data: For manufacturer testing agency.

E. Material Certificates: For each of the following, signed by manufacturers:

1. Cementitious materials.

2. Admixtures.

3. Curing compounds.

4. Bonding agents.

5. Adhesives.

6. Course Aggregate Gradation.

7. Fine Aggregate Gradation.

F. Floor surface flatness and levelness measurements indicating compliance with specified tolerances.

G. Field quality-control test and inspection reports.

H. Material Test Reports: for the following, from a testing agency acceptable to the Engineer and Owner, indicating compliance with requirements:

1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.

I. Ready-Mix concrete.

1. Provide delivery tickets for ready-mix concrete, or weigh-masters certificate, per ASTM C94 including weights of cement and each size aggregate and amount of water added at the plant and record of pours.

2. Keep record showing time and place of each pour (placement) of concrete, together with transit-mix delivery slips certifying the contents of the pour (placement).

3. Furnish records to Engineer upon request.

1.5 Quality Assurance

A. Comply with the requirements outlined in the listed references, unless modified by the contract documents.

B. Installer Qualifications: Project personnel qualified as ACI-certified Flatwork Technician and Finisher and a supervisor who is an ACI-certified Concrete Flatwork Technician.

C. Manufacturer Qualifications: A firm with a minimum of 5 years’ experience in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

2. The criteria hereinafter set out are solely for the purpose of establishing required mixture proportions and do not constitute a basis for confirming the adequacy of concrete strength.

D. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C1077 and ASTM E329 for testing indicated.

1. Personnel conducting field tests and/or laboratory tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

2. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

E. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

F. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

G. Pre-installation Conference: Conduct conference at Project site prior to beginning the work.

1. Representatives of each entity directly concerned with cast-in-place concrete are required to attend.

Part 2 Products

2.1 Manufacturers

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Products: Subject to compliance with requirements products that may be incorporated into the work include but are not limited to products specified.

2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 Concrete Materials

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:

1. Portland Cement (Non-hydraulic Above Grade Structures): ASTM C150, Type I or II, or combination of Type I with fly ash.

2. Portland Cement (Hydraulic and/or Below Grade Structures): ASTM C150 Type II with fly ash.

3. Fly Ash: ASTM C618, Class C or F fly ash.

   a. Limit fly ash content to maximum of 20% of cementitious materials by weight.

   b. Class C fly ash is not permitted without written approval from the Engineer.

B. Normal-Weight Aggregates: ASTM C33, Class 3S coarse aggregate or better, graded. Provide aggregates from a single source with documented service record data of at least 10 years satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials.

1. Maximum Coarse-Aggregate Size: 1” nominal.

2. Fine aggregate:

   a. Free of materials with deleterious reactivity to alkali in cement.

   b. Provide fine aggregate consisting of clean, natural sand or prepared from crushed stone or crushed gravel.

   c. Except as otherwise specified, grade fine aggregate from coarse to fine in accordance with ASTM C33.

3. Coarse aggregate:

   a. Provide coarse aggregate consisting of gravel or crushed stone made up of clean, hard, durable particles free from calcareous coatings, organic matter, or other foreign substances.

   b. Not exceeding 15 percent by weight, of thin or elongated pieces having length greater than 5 times average thickness.

   c. Free of deleterious substances.

   d. Coarse aggregate shall be washed prior to combining in concrete mix.

4. Grading:

   a. Aggregate for building elements and hydraulic structures: In accordance with ASTM C33, #57.

C. Water: ASTM C94 and potable (not recycled water).

   1. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement for non-hydraulic structures and 0.10 percent by weight of cement for hydraulic structures.

2.3 Admixtures

A. Air-Entraining Admixture: In accordance with ASTM C260.

B. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

   1. Water-Reducing Admixture: ASTM C494/C494M, Type A.

   2. Retarding Admixture: ASTM C494/C494M, Type B.

   3. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.

   4. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.

   5. High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.

2.4 Concrete Mixtures, General

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.

   1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.

B. Admixtures: Use admixtures according to manufacturer's written instructions.

   1. Use water-reducing or high-range water-reducing admixture in concrete, as required, for placement and workability.

   2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

   3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.

2.5 Concrete Mixtures

A. Proportion normal-weight concrete mixture as follows for all structural elements:

1. Minimum Compressive Strength: 4,500 psi at 28 days.
2. Maximum Water-Cementitious Materials Ratio: 0.42.
3. Minimum Cementitious Materials Content: 535 lb. /cu yd.
4. Slump Limit: 8-inches max for concrete with verified slump of 2 to 4-inches before adding high range water-reducing admixture or plasticizing admixture per ACI 301.
5. Air Content: 5% percent, plus or minus 1.5% at point of delivery.

B. Proportion normal-weight concrete mixture as follows for all non-structural elements:

1. Minimum Compressive Strength: 3,000 psi at 28 days.
2. Maximum Water-Cementitious Materials Ratio: 0.45.
3. Slump Limit: 8 inch for concrete with verified slump of 2” to 4”: before adding high-range water-reducing admixture or plasticizing admixture per ACI 301.
4. Air content: 5 1/2%, plus or minus 1.5% at point of delivery.

C. All slabs with a troweled finish shall have a maximum air content of 3%.

2.6 Concrete Mixing

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C94/C94M and ASTM C1116, and furnish batch ticket information.

1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For mixer capacity of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
2. For mixer capacity larger than 1 cu. yd., increase mixing times by 15 seconds for each additional 1 cu. yd.
3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixture

time, quantity, and amount of water added. Record approximate location of final deposit in structure.

2.7 Curing Materials

A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

B. Absorptive Cover: AASHTO M182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. when dry.

C. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.

D. Water: Potable.

E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type 1, Class B, dissipating.

F. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C1315, Type 1, Class A. Compatible with penetrating liquid floor treatment for surfaces specified to receive penetrating liquid floor treatment.

Part 3 Execution

3.1 Concrete Placement

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301.

   1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

C. Hydraulic Structures:

   1. Provide a minimum of 7-days between adjacent concrete pours. Additionally, concrete strength shall meet or exceed 70% of the specified design compressive strength prior to placing adjacent pours.

D. Joints:

   1. Joint material and preparation shall be in accordance with 03 15 00 - Concrete Accessories.

   2. Joints shall be placed at locations shown or as indicated on the drawings. If additional joints are required, the contractor may submit joint placement to the Engineer for review.

E. Walls:

1. Deposit concrete continuously in one layer or in horizontal layers as shown on the drawings.

2. Deposit concrete in horizontal layers of depth not to exceed formwork design pressures and in a manner to avoid inclined construction joints.

3. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.

4. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity.

F. Floors/Slabs:

1. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

2. Maintain reinforcement in position during concrete placement.

3. Screed slab surfaces with a straightedge and strike off to correct elevations.

4. Slope surfaces uniformly to drains where required.

5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

G. Cold-Weather Placement: Comply with ACI 306.1 and as follows.

1. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

2. When average high and low temperature is expected to fall below 40 deg F for three successive days, maintain delivered concrete temperature within the temperature range required by ACI 301.

3. All embedded items such as wall pipes, embed frames, steel guide rails, channels, etc. (not including conduit and reinforcing) shall be considered “massive embedments” per ACI 306.1 and are required to be kept above 32 deg F during placement and for the first 48 hours after placement. Contractor shall take the necessary measures; including insulated blankets, heated blankets, and heaters; to insure items are kept above 32 deg F. All other methods shall be submitted to the Engineer for approval.

4. Do not use frozen materials or materials containing ice or snow.

5. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

6. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators.

H. Hot-Weather Placement: Comply with ACI 305 and as follows:

1. Maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is included in total amount of mixing water. Using liquid nitrogen to cool concrete is contractor's option, but liquid nitrogen should not replace water.

2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

3.2 Concrete Wall Finishes

A. Type W-1 (Ordinary Wall Finish):

1. Patch tie holes.

2. Knock off projections.

3. Patch defective areas.

B. Type W-2 (Smooth Wall Finish):

1. Patch tie holes.

2. Grind off projections, fins, and rough spots.

3. Patch defective areas and repair rough spots resulting from form release agent failure or other reasons to provide smooth uniform appearance.

C. Type W-3 (Smooth-Rubbed Finish)

1. Patch tie holes.

2. Grind off projections, fins, and rough spots.

3. Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.

D. Type W-5 (Finish for Painting or Coating):

1. Patch tie holes.

2. Grind off projections, fins, and rough spots.

3. Patch and repair defective areas as specified for Type W-2.

4. Apply paint or coating system as specified in Section 09 90 15 - Paints and Coatings.

3.3 Concrete Slab Finishes

A. General:

1. Finish slab concrete per the requirements of ACI 302.1R

2. Use manual screeds, vibrating screeds, or roller compacting screeds to place concrete level and smooth.

3. Do not use “Jitterbugs” or other special tools designed for the purpose of forcing coarse aggregate away from the surface and allowing a layer of mortar.

4. Do not dust surface with dry materials.

5. Use evaporation retardant.

B. Type S-1 (Steel Troweled Finish):

1. Finish by screeding and floating with straightedges to bring surfaces to required finish elevation, use evaporation retardant.

2. While concrete is still green, but sufficiently hardened to bear a person’s weight without deep imprint, wood float to true, even plane with no coarse aggregate visible.

3. Use sufficient pressure on wood floats to bring moisture to surface.

4. After surface moisture has disappeared, hand trowel concrete to produce smooth, impervious surface, free from trowel marks.

5. Final troweling shall produce a ringing sound from trowel.

6. Do not use dry cement or additional water during troweling.

7. Power Finishing:

a. An approved power machine may be used in lieu of hand finishing in accordance with directions of machine manufacturer.

b. Do not use power machine when concrete has not attained the necessary set to allow finishing without introducing high and low spots in slab.

c. Do first steel troweling for slab S-1 finish by hand.

C. Type S-2 (Wood Float Finish):

1. Finish slabs to receive fill and mortar setting beds by screeding with straight edges to bring surface to required finish plane.

2. Wood float finish to compact and seal surface.

3. Remove laitance and leave surface clean.

4. Coordinate with other finish procedures.

D. Type S-3 (Underside Elevated Slab Finish): When forming is removed, grind off projections on underside of slab and patch defective areas, including small shallow air pockets where schedule of concrete finishes requires painting or protective coating.

E. Type S-5 (Broomed Finish):

1. Finish as specified for Type S-1 floor finish, except omit final troweling and finish surface by drawing a fine-hair broom lightly across the surface.

2. Broom in same direction and parallel to expansion joints, or, in the case of inclined slabs, perpendicular to scope, except for round roof slab, broom surface in radial direction.

F. Type S-6: The top surfaces of basins in which raking mechanisms are to be installed

1. Slabs shall be finished by sweeping in cement grout with the mechanism. The cement grout to be used shall be composed of one part Portland cement and two parts sand.

2. The sweeping-in process shall be performed under the supervision of a factory representative of the equipment manufacturer.

3. The slab upon which the grout is to be applied shall receive a Type S-5 finish except that after leveling and floating, it shall be raked in such a manner as to provide a good bond for the grout. Raking shall develop a pattern with a depth of 1/4” every 2”. Before grout is deposited on the slab, it shall be thoroughly cleaned, wet down with clean water and lightly dusted with neat cement immediately prior to placement of the grout.

3.4 Schedule of Concrete Finishes

A. Form Tolerances: As specified in Section 03 11 00 - Concrete Formwork.

B. Provide concrete finishes as scheduled:

Area	Type of Finish	Required Form Tolerances
EXTERIOR WALL SURFACES		
Above grade/exposed (above a point 12” below finish grade)	W-3	W-B

Area	Type of Finish	Required Form Tolerances
Backfilled (below a point 12” below final grade)	W-1	W-A
INTERIOR WALL SURFACES		
Hydraulic Structures and piping galleries	W-3	W-A
Interior surface of walls in containment area	W-5	W-A
Buildings and other dry areas	W-3	W-B
EXTERIOR SLABS		
Exposed Roof slab or Slab-on-grade for non-hydraulic structures	S-5	
Roof slab or Top of Wall for Hydraulic Structures	S-1	
Other water holding tanks and basins	S-1	
Stairs and landings	S-5	
Other exterior slabs/pads	S-1	
Top surfaces of basins in which raking mechanisms are to be installed	S-6	
INTERIOR SLABS		
Non-Hydraulic areas such as pipe galleries and slabs-on-grade	S-1	
Underside of elevated slabs	S-3	

3.5 Concrete Protecting and Curing

A. General: Contractor shall submit a schedule and sequence of concrete placement to the Engineer for review. See 03 11 00 - Concrete Formwork for additional requirements.

B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Cure concrete according to ACI 308.1, by one or a combination of the following methods:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

    a. Water.

    b. Continuous water-fog spray.

    c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

2. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

    a. Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer unless manufacturer certifies curing compound will not interfere with bonding of floor covering used on Project.

Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

3.6 Repairing Concrete

A. General:

1. Any defective areas or areas considered to be structurally deficient shall be removed to the extents required by the Engineer. The Engineer has the option of calling for the removal of the entire section, if the damage is such that a repair will not be a suitable option. All work required to correct the defect will be the responsibility of the Contractor and will be paid for by the Contractor.

2. Repair cracks, as defined by Defective Areas, with crack repair epoxy as specified in Section 03 64 00 - Concrete Repair Crack Injection.

3. Repair concrete surfaces defects, as defined by Defective Areas, using one of the materials specified in Section 03 01 00 - Concrete Surface Repair Systems.

4. Develop repair techniques with material manufacturer.

5. Dress surface of repair that will remain exposed to view to match color and texture of adjacent surfaces.

B. Tie Holes:

1. Fill with nonshrink grout as specified in Section 03 60 00 - Grout.

2. Match color of adjacent concrete.

3. Compact grout using steel hammer and steel tool to drive grout to high density. Cure grout with water.

C. Alternate Form Ties-Through-Bolts:

1. Seal through-bolt hole by sandblasting or mechanically cleaning and roughening entire interior surface of hole, coating roughened surface with bonding agent .

2. Install elastic vinyl plug according to manufacturer’s instructions.

3. Dry pack entire hole on each side of plug with non-shrink grout, as specified in Section 03 60 00 - Grout.

4. Compact grout using steel hammer and steel tool to drive grout to high density. Cure grout with water.

D. Exposed Metal Objects:

1. Metal objects not intended to be exposed in as-built condition of structure including wire, nails, and bolts, shall be removed by chipping back concrete to depth of 1 inch and then cutting or removing metal object.

2. Repair areas of chipped-out concrete per requirements of Section 03 01 00 - Concrete Surface Repair Systems.

E. Blockouts at Pipes or Other Penetrations:

1. Meet details shown or submit proposed blockouts for review.

2. Use non-shrink, nonmetallic grout, Category I or II as specified in Section 03 60 00 - Grout.

3.7 Field Quality Control

A. Testing and Inspecting: Owner will engage a qualified testing and inspection agency to perform field tests and inspections and prepare test reports. Payment of the testing and inspection agency shall be by the Contractor from the contract allowance for independent testing in accordance with contract documents.

B. Inspections:

1. Steel reinforcement placement.

2. Cast-in-Place bolts, plates, and headed studs.

3. Verification of use of required design mixture.

4. Concrete placement, including conveying and depositing.

5. Curing procedures and maintenance of curing temperature.

6. Verification of concrete strength before removal of shores and forms from beams and slabs.

C. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C172/C172M shall be performed according to the following requirements:

1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture, plus one sample for each additional 50 cu. yd. or fraction thereof.

2. Slump: ASTM C143/C143M; one test at point of placement for each composite sample. Perform additional tests when concrete consistency appears to change.

3. Air Content: ASTM C173/C173M, pressure method, for normal-weight concrete; one test for each composite sample.

4. Concrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is 40 deg F and below, and when 80 deg F and above.

5. Compression Test Specimens: ASTM C31/C31M.

   a. Cast three sets of two 6”x12” cylinder specimens (or three sets of three 4”x8” cylinder specimens) for each composite sample.

      1) All cylinders shall be laboratory-cured in accordance with ASTM requirements.

6. Compressive-Strength Tests: ASTM C39/C39M

   a. Test one set of cylinders at 7 days and one set cylinders at 28 days. The additional set of cylinders will be retained for subsequent testing, as required by the Engineer.

   b. A compressive-strength test shall be the average compressive strength from a set of two 6”x12” specimens (or a set of three 4”x8” specimens) obtained from the same composite sample and tested at age indicated.

7. Acceptance of concrete strength for the mix design shall be based on compressive strength results for 28-day tests. Acceptance of the concrete strength for the mix design shall be determined in accordance with ACI 318 requirements.

8. Strength of each individual concrete sample will be satisfactory if the average of the set for the 28-day compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

9. Test results shall be reported in writing to Engineer, Owner, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, placement of concrete batch in Work, design compressive strength at 28 days, concrete mixture identification, slump test results, air content test results, and compressive strength test results.

10. Additional testing and inspection, will be performed, as required by the Engineer and at Contractor's expense, when test results indicate requirements have not been met.

    a. The third set of cylinders may be broken at a concrete age as specified by the Engineer.

    b. Testing and inspection agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42/C42M or by other methods, as directed by Engineer.

    c. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive devices may be permitted by Engineer.

11. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

D. Measure floor and slab flatness and levelness according to ASTM E 1155 48 hours after finishing. Specified overall values of flatness F(f)=25; and levelness F(L)=20; with minimum local values, F(f)=17 and F(L)=15.

   1. F(L) value only applies to elevated slabs after shoring has been removed.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Non-shrink grout.

2. Topping grout.

3. Concrete Fill.

4. Cement grout for pipe invert fill.

5. Construction joint mortar.

6. Cement grout for pipe abandonment.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.2 References

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

1. ASTM International (ASTM):

a. C 230, Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.

b. C 1107, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).

B. Cement Grout (Non-shrink)

1. Corps of Engineers (COE):

a. CRD-C 611, Flow of Grout for Preplaced Aggregate Concrete.

b. CRD-C 621, Specification for Non-Shrink Grout.

1.3 Submittals

A. Product data for each type of product indicated.

B. Certified test results verifying compliance with compressive strength, shrinkage and expansion requirements and manufacturer's literature containing instructions and recommendations on the mixing, handling, placement and appropriate uses for each type of non-shrink and epoxy grout.

C. Fine aggregate gradation.

D. Grout Mixture Compressive Strength.

1. Testing shall be in accordance with ACI 350.

2. Testing results shall be from tests conducted within the 12-month period prior to this submittal.

3. Provide one copy of 30 consecutive strength test results, for each mix design used, from a record of past performance.

4. Or one copy of the project specific laboratory trial mix design and testing results, for each concrete mix used in this project.

E. Qualification for testing agency.

F. Material test reports: For the following from a qualified testing agency, indicating compliance with requirements:

1. Aggregates, Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.

2. Non-shrink grout.

3. Epoxy grout.

G. Material certificates: For each of the following, signed by manufacturers:

1. Cementitious materials.

2. Non-shrink grout.

3. Epoxy grout.

H. Field quality-control tests and observation reports.

I. Ready mix concrete (Cement Grout).

1. Provide delivery tickets for ready-mix concrete (cement grout) or weigh master's certificate per ASTM C 94, include weights of cement and each size aggregate and amount of water added at the plant and a record of placements. Record the amount of water added at the job site on the delivery

ticket. Water added at the plant shall account for the moisture in aggregate. If water is added at the job site, then the total water content shall not exceed the water content of the approved design mix.

2. Keep records showing time and place of each placement of concrete, joint mortar bed material or cement grout, together with transit delivery slips certifying the contents of the placement. Furnish records to Engineer.

J. Joint Mortar Bed: Provide material analysis and certification for each placement.

K. Shop Drawings:

1. Product data of grouts.

2. Curing method for grout.

3. Mix design of cement-sand grout mixture for pipe invert/structure fill.

4. Mix design of Joint Mortar Bed.

L. Information Submittals:

1. Manufacturer’s written instructions for mixing of grout.

2. Manufacturer’s Certificate of Compliance: Grout free from chlorides and other corrosion causing chemicals.

3. Manufacturer’s Certificate of Proper Installation.

4. Statements of Qualification: Non-shrink grout manufacturer’s representative.

5. Test Reports: Test report for 24-hour evaluation of non-shrink grout.

1.4 Qualifications

A. Manufacturer’s qualifications for cement grout and joint mortar bed: A firm experienced in manufacturing ready-mixed concrete products and a firm that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.

2. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I, Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

C. Source limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from one source and obtain admixtures through one source from a single manufacturer.

D. Non-shrink Grout Manufacturer's Representative: Authorized and trained representative of grout manufacturer, with minimum of 1 year experience that has resulted in successful installation of grouts similar to those for this Project.

E. For grout suppliers not listed herein, provide completed 24-hour Evaluation of Non-shrink Grout Test Form, attached at the end of this section. Independent testing laboratory to certify that testing was conducted within last 18 months.

1.5 Guarantee

A. Manufacturer's guarantee shall not contain disclaimer on the product data sheet, grout bag, or container limiting responsibility to only the purchase price of products and materials furnished.

B. Manufacturer guarantees participation with Contractor in replacing or repairing grout found defective due to faulty materials, as determined by industry standard test methods.

Part 2 Products

2.1 Concrete Materials

A. Cementitious Material: Use the following cementitious materials, of the same type, brand and source throughout project:

1. Portland Cement: ASTM C 150

    a. Type I or II.

    b. Or combination of Type I with fly ash.

2. Fly Ash: ASTM C 618, Class F.

    a. Limit fly ash content to maximum of 20% of cementitious materials by weight.

    b. Class C fly ash is not permitted without written approval from the Engineer.

B. Fine aggregates: ASTM C 33, Class 4S or better, graded. Aggregates shall be free of materials with deleterious reactivity to alkali in cement. Aggregates for cement grout and/or mortar bed shall be provided from the same source as aggregate for the cast-in-place concrete.

C. Water: ASTM C 94 and potable.

2.2 Admixtures

A. Comply with Section 03 30 00 - Cast-In-Place Concrete.

2.3 Non-shrink Grout Schedule

A. Furnish non-shrink grout for applications in grout category in the following schedule:

Application	Temperature Range 40 to 100 °F	Max. Placing Time 20 min	Greater than 20 min
Filling tie hole	I	I	I
Machine bases 25 hp or less	II	II	II
Through-bolt openings	II	II	II
Patching Concrete Walls	II	II	II
Machine bases 26 hp and up	III	III	III
Base plates and/or soleplates with vibration, thermal movement, etc.	III	III	III
Other applications not listed	II	II	II

2.4 Non-Shrink Grout

A. Category I:

1. Non-metallic and non-gas-liberating.

2. Pre-packaged natural aggregate grout requiring only the addition of water.

3. Test in accordance with ASTM C1107:

    a. Flowable consistency 140%, five drops in 30 seconds, in accordance with ASTM C230.

    b. Flowable for 15 minutes.

4. Grout shall not bleed at maximum allowed water.

5. Minimum strength of flowable grout, 3,000 psi at 3 days, 5,000 psi at 7 days, and 7,000 psi at 28 days.

6. Manufacturers and Products equal to:

    a. Chemrex, Inc., Shakopee, MN; Set Grout.

    b. Euclid Chemical Co., Cleveland, OH; NS Grout.

    c. Dayton Superior Corp., Miamisburg, OH; 1107 Advantage Grout.

d. US MIX Products, Denver, CO; US Spec Multi-Purpose Grout.

e. L & M Construction Chemicals, Inc., Omaha, NE; Duragrout.

f. Master Builders.

B. Category II:

1. Non-metallic, non-gas-liberating.

2. Pre-packaged natural aggregate grout requiring only the addition of water.

3. Aggregate shall show no segregation or settlement at fluid consistency - at specified times or temperatures.

4. Test in accordance with COE CRD-C 621 and ASTM C 1107, Grade B:

a. Fluid consistency 20 to 30 seconds in accordance with COE CRD-C 611.

b. Temperatures of 40, 80, and 100 °F.

5. 1 hour after mixing, pass fluid grout through flow cone with continuous flow.

6. Minimum strength of fluid grout, 3,500 psi at 1 day, 4,500 psi at 3 days, and 7,500 psi at 28 days.

7. Maintain fluid consistency when mixed in 1 to 9 yard loads in ready- mix truck.

8. Manufacturers and Products equal to:

a. Chemrex, Inc., Shakopee, MN; Master Flow 928.

b. Five Star Products Inc., Fairfield, CT; Five Star 100.

c. Euclid Chemical Co., Cleveland, OH; Hi Flow Grout.

d. Dayton Superior Corp., Miamisburg, OH; Sure Grip High Performance Grout.

e. L & M Construction Chemicals, Inc., Omaha, NE; Crystex.

f. Master Builders.

C. Category III

1. Metallic and non-gas-liberating flowable fluid.

2. Prepackaged aggregate grout requiring only the addition of water.

3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.

4. Test in accordance with CRD-C 621 and ASTM C 1107, Grade B:

   a. Fluid consistency 20 to 30 seconds in accordance with CRD-C 611.

   b. Temperatures of 40 and 100 °F.

5. 1 hour after mixing, pass fluid grout through flow cone with continuous flow.

6. Minimum strength of grout, 4,000 psi at 1 day, 5,000 psi at 3 days, and 9,000 psi at 28 days.

7. Maintain fluid consistency when mixed in 1 to 9 yard loads in ready-mix truck.

8. Manufacturers and Products equal to: Chemrex, Inc., Shakopee, MN; EMBECO 885.

2.5 Topping Grout and Concrete/Grout Fill

A. Where fill is thicker than 3-inches, non-structural concrete, per Section 03 30 00 - Cast-In-Place Concrete, may be used subject to Engineer's approval.

B. Grout for topping of slabs and concrete/grout fill for built-up surfaces of tank, channel and basin bottoms shall be composed of cement, fine aggregate, coarse aggregate, water and admixtures proportioned and be mixed as indicated. Bonding Agent shall be used to enhance adhesion to basin concrete. Materials and procedures indicated for normal concrete in Section 03 30 00 - Cast-In-Place Concrete, shall apply unless indicated otherwise.

C. Topping grout and concrete/grout fill shall be:

   1. Minimum Compressive Strength: 4,000 psi at 28 days.

   2. Minimum of 535 pounds of cement per cubic yard.

   3. Maximum water cement ratio of 0.45.

   4. Air content: 5 1/2%, plus or minus 1.5% at point of delivery.

D. Aggregate shall be graded as follows:

U.S. STANDARD SIEVE SIZE	PERCENT BY WEIGHT PASSING
1/2 inch	100
3/8 inch	90-100
No. 4	20-55
No. 8	5-30
No. 16	0-10
No. 30	0

2.6 Cement-Grout (Cement-Sand Grout) Mixture for Pipe Invert/Structure Fill/Pipe Abandonment

A. Prepare design mixture proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301. Submit proposed mixture design to Engineer for review. Comply with Section 03 30 00 - Cast-in-Place Concrete and as follows.

1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based upon laboratory trial mixtures.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than Portland cement in concrete and cement grout as follows:

1. Fly Ash: 20 percent maximum unless approved in writing by the Engineer.

C. Admixtures: All materials other than Portland cement, water and aggregates that are added to the concrete or cement grout, shall be subject to the approval of the Engineer. If so approved, use admixtures according to manufacturer's written instructions.

1. Use water reducing, high-range water-reducing or plasticizing admixture in concrete, as required, for placement and workability.

2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

3. Use water-reducing admixture in pumped concrete, concrete for heavy-use slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.

D. Minimum compressive strength: 2,000 psi at 28 days.

E. Air content: ASTM C 94, 5 percent, plus or minus 1.0 percent at point of delivery.

F. Aggregate shall be sand, three parts sand to one part cementitious material by volume. The sand gradation shall be such that 100% shall pass the No. 16 sieve and not more than 30% shall be retained on a No. 30 sieve.

G. Water - cementitious material ratio. The Contractor shall submit a proposed mix design to the Engineer for review. The amount of water shall be the minimum amount of water necessary to make a workable mixture.

H. Slump: Maximum of 4 inches.

Part 3 Execution

3.1 Non-Shrink Grout

A. General: Mix, place, and cure non-shrink grout in accordance with grout Manufacturer's representative's training instructions.

B. Form Tie or Through-Bolt Holes: Provide non-shrink grout, Category I and II, fill space with dry pack dense grout hammered in with steel tool and hammer. Through-bolt holes; coordinate dry pack dense grout application with vinyl plug in Section 03 11 00 - Concrete Formwork, and bonding agent in Section 03 30 00 - Cast-In-Place Concrete.

C. Grouting Machinery Foundations:

1. Block out original concrete or finish off at distance shown below bottom of machinery base with grout. Prepare concrete surface by sandblasting, chipping, or by mechanical means to remove any soft material.

2. Set machinery in position and wedge to elevation with steel wedges, or use cast-in leveling bolts.

3. Form with watertight forms at least 2” higher than bottom of plate.

4. Fill space between bottom of machinery base and original concrete in accordance with Manufacturer’s representative’s training instructions.

3.2 Cement Grout

A. Place cement grout topping over concrete slabs where indicated on the drawings. Place in accordance with the procedures of this section and the manufacturer’s or equipment supplier’s recommendations. The finish surface of the grout topping shall be similar to a steel trowel finish and which will facilitate the proper operation of the mechanical equipment. The finish of the structural slab below the cement grout topping shall be a heavy broom finish.

B. Where cement grout is to be placed without mechanical equipment, the fresh surface of the cement grout shall be a smooth trowel finish. Placement procedure of cement grout at areas with mechanical equipment includes:

1. Notify Project Representative or Engineer a minimum of 48 hours in advance of placement.

2. Make a trial cement grout batch of not less than 1/2 cubic yard to allow time for adjustment in mix design if required.

3. Clean the exposed structural slab by sandblasting and washing clean.

4. Thoroughly broom a neat cement paste containing an epoxy binder into the concrete slab surface immediately ahead of placing the cement grout topping.

5. Place cement grout topping in a continuous operation. If grouting operations are interrupted, clean the edge of the previously placed topping by water jetting and add a coat of cement paste to provide a bond to the fresh topping.

6. Temporarily equip the mechanical screed mechanism on at least two arms with a 2-inch by 10 inch continuous wood plate with light gauge metal angles and surface plates or channels. The bottom of the screed plates or steel plates shall be adjustable and set to elevations which allow the proper

operation of equipment and as recommended by the equipment manufacturer or supplier.

7. Screed the topping immediately after consolidation with vibrators or tampers and provide a steel trowel finish.

8. Cure cement grout topping with water and cover with PVC sheeting to prevent damage from foot traffic for seven days. When/If the cement grout topping is found not to be acceptable, remove and replace. Cement grout topping not acceptable shall include, but is not limited to, poor bonding with the concrete slab, low strength, excessive cracking and unevenness in finish or elevation.

3.3 Non-Shrink Grout

A. Used for repair of holes and defects and at locations indicated where epoxy grout is not indicated. Execution shall follow manufacturer’s recommendations.

B. Base plates and equipment where indicated. Execution shall follow manufacturer’s recommendations.

3.4 Epoxy Grout

A. Used to embed all anchor bolts and reinforcing steel set in grout, specific machinery base plates as indicated and at other locations where indicated. Execution shall follow manufacturer’s recommendations.

3.5 Field Quality Control

A. Evaluation and Acceptance of Non-Shrink Grout:

1. Consistency: As specified in Article NON-SHRINK GROUT. Grout with consistencies outside range requirements shall be rejected.

2. Segregation: As specified in Article NON-SHRINK GROUT. Grout when aggregate separates shall be rejected.

3.6 Manufacturer’s Services

A. General: Coordinate demonstrations, training sessions, and applicable site visits with grout manufacturer’s representative.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Epoxy/polyurethane injection system.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.2 References

A. ASTM International (ASTM):

1. D 638, Standard Test Method for Tensile Properties of Plastics.

2. D 648, Standard Test Method for Deflection of Plastics under Flexural Load.

3. D 695, Standard Test Method for Compressive Properties of Rigid Plastics.

4. D 790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

1.3 Definitions

A. Epoxy/polyurethane Injection Repair Areas: Areas deemed to be defective and requiring large crack repair.

B. Defective Areas: Surface defects that include honeycomb, rock pockets, and indentations greater than 3/16"; cracks 0.010" wide and larger, as well as any crack that leaks, for hydraulic structures and below grade habitable spaces; cracks 0.015" wide and larger in non-hydraulic structures; spalls; chips; air bubbles greater than ¾" in diameter; pinholes; bug holes; embedded debris; fins and other projections; form pop-outs; texture irregularities; and stains that cannot be removed by cleaning.

C. Large Cracks: Wider than 0.015".

D. Small Cracks: Width greater than or equal to 0.010" and less than or equal to 0.015", as well as any smaller cracks that leak.

1.4 Submittals

A. Information Submittals:

1. Manufacturer’s recommended surface preparation procedures and application instructions for epoxy or polyurethane injection system.

2. Manufacturer’s product data for epoxy/polyurethane injection system.

3. Statements of Qualification for Epoxy/Polyurethane Injection Material:

   a. Manufacturer’s site representative.

   b. Injection applicator.

   c. Injection pump operating technician.

1.5 Quality Assurance

A. Qualifications for Epoxy/Polyurethane Injection Staff:

1. Manufacturer’s Site Representative:

   a. Capable of instructing successful methods for restoring concrete structures utilizing injection process.

   b. Understands and is capable of explaining technical aspects of correct material selection and use.

   c. Experienced in the operation, maintenance, and troubleshooting of application equipment.

2. Injection crew and job foreman shall provide written and verifiable evidence showing compliance with the following requirements:

   a. Licensed and certified by epoxy/polyurethane Manufacturer.

   b. Minimum 3 years’ experience in successful epoxy/polyurethane injection for at least 10,000 linear feet of successful crack injection including 2,000 linear feet of wet crack injection to stop water leakage.

1.6 Delivery, Storage, And Handling

A. Packing and Shipping: Package adhesive material in new sealed containers and label with following information:

1. Manufacturer’s name.

2. Product name and lot number.

3. ANSI Hazard Classification (formerly SPI Classification).

4. ANSI recommended precautions for handling.

5. Mix ratio by volume.

B. Storage and Protection: Store adhesive containers at ambient temperatures below 120 °F and above 32 °F.

Part 2 Products

2.1 Manufacturers

A. Epoxy Injection Material equal to:

1. Sika Corp., Lyndhurst, NJ; Sikadur-52 N/LP (or approved equal).

B. Polyurethane Injection Material equal to:

1. Sika Corp., Lyndhurst, NJ; Sika Injection-215 (or approved equal).

2. Sika Corp., Lyndhurst, NJ; Sika Injection-304 (or approved equal).

3. Sika Corp., Lyndhurst, NJ; Sika Injection-307 (or approved equal).

2.2 Surface Seal

A. Sufficient strength and adhesion for holding injection fittings firmly in-place, and to resist pressures preventing leakage during injection.

B. Capable of removal after injection adhesive has cured.

Part 3 Execution

3.1 General

A. Large Cracks: Repair by injection of epoxy or polyurethane as noted on drawings.

B. Small Cracks: Repair according to 03 01 00 - Concrete Surface Repair Systems.

3.2 Preparation

A. Clean cracks in accordance with epoxy/polyurethane manufacturer’s instructions.

B. Clean surfaces adjacent to cracks from dirt, dust, grease, oil, efflorescence, and other foreign matter detrimental to bond of surface seal system.

C. Do not use acids and corrosives for cleaning, unless neutralized prior to injecting epoxy/polyurethane.

3.3 Application

A. Sealing: Apply surface seal in accordance with Manufacturer’s instructions to designated crack face prior to injection. Seal surface of crack to prevent escape of injection epoxy/polyurethane.

B. Entry Ports:

1. Determine space between entry ports equal to thickness of concrete member to allow epoxy/polyurethane to penetrate to the full thickness of the wall.

2. Clean entry ports after drilling.

3. Space entry ports close together to allow adjustment of injection pressure to obtain minimum loss of epoxy/polyurethane to soil at locations where:

    a. Cracks extend entirely through wall.

    b. Backfill of walls on one side.

    c. Difficult to excavate behind wall to seal both crack surfaces.

C. Epoxy/polyurethane Injection:

1. Store epoxy/polyurethane at minimum of 70 °F.

2. Start injection into each crack at lowest elevation entry port.

3. Continue injection at first port until adhesive begins to flow out of port at next highest elevation.

4. Plug first port and start injection at second port until adhesive flows from next port.

5. Inject entire crack with same sequence.

D. Finishing:

1. Cure epoxy/polyurethane adhesive after cracks have been completely filled to allow surface seal removal without draining or runback of epoxy/polyurethane material from cracks.

2. Remove surface seal from cured injection adhesive.

3. Finish crack face flush with adjacent concrete.

4. Indentations or protrusions caused by placement of entry ports are not acceptable.

5. Remove surface seal material and injection adhesive runs and spills from concrete surfaces.

3.4 Equipment

A. Portable, positive displacement type pumps with in-line metering to mix two adhesive components, and inject mixture into crack, and as required by injection system manufacturer.

3.5 Field Quality Control

A. Epoxy/Polyurethane Adhesive Two Component Ratio Tests:

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

2. Adjust discharge pressure to 160 psi for both adhesive components.

3. Simultaneously discharge both adhesive components into separate calibrated containers.

4. Compare amounts simultaneously discharged into calibrated containers during same time period to determine mix ratio.

5. Complete test at 160 psi discharge pressure and repeat procedure for 0 psi discharge pressure.

6. Run ratio test for each injection unit at beginning and end of each injection work day, and when injection work has stopped for more than 1-hour.

7. Document and maintain complete accurate records of ratios and pressure checks.

B. Injection Pressure Test:

1. Disconnect mixing head of injection equipment and connect two adhesive component delivery lines to pressure check device.

2. Pressure Check Device:

a. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing of valve.

b. Pressure gauge capable of sensing pressure buildup behind each valve.

3. Close valves on pressure check device and operate equipment until gauge pressure on each line reads 160 psi.

4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 psi within 3 minutes.

5. Run pressure test for each injection equipment unit:

    a. Beginning and end of each injection work day.

    b. When injection work has stopped for more than 1-hour.

6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Structural steel.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.

a. Section 05 50 00 - Metal Fabrications, for steel lintels or shelf angles not attached to structural-steel frame, miscellaneous steel fabrications, and other metal items not defined as structural steel.

b. Section 09 90 15 - Paints and Coatings, for surface preparation and priming requirements.

1.2 Definitions

A. Structural Steel: Elements of structural-steel frame, as classified by AISC "Code of Standard Practice for Steel Buildings and Bridges," that support design loads.

1.3 Submittals

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

B. Shop Drawings: Show fabrication of structural-steel components.

1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.

2. Include embedment drawings.

3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.

4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pre-tensioned and slip-critical high-strength bolted connections.

C. Delegated-Design Submittal: For structural-steel connections indicated to comply with design loads, include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

D. Welding certificates.

E. Qualification Data: For Installer and fabricator.

F. Mill Test Reports: Signed by Manufacturers certifying that the following products comply with requirements:

1. Structural steel including chemical and physical properties.

2. Bolts, nuts, and washers including mechanical properties and chemical analysis.

3. Shop primers.

G. Source quality-control test reports.

1.4 Quality Assurance

A. Fabricator Qualifications: A qualified fabricator that participates in the AISC Quality Certification Program and is designated an AISC-Certified Plant, Category STD.

B. Installer Qualifications: A qualified installer who participates in the AISC Quality Certification Program and is designated an AISC-Certified Erector, Category CSE.

C. Welding: Qualify procedures and personnel according to AWS D1.1, “Structural Welding Code--Steel.”

D. Comply with applicable provisions of the following specifications and documents:

1. AISC “Code of Standard Practice for Steel Buildings and Bridges.”

2. AISC “Seismic Provisions for Structural Steel Buildings” and “Supplement No.2.”

3. AISC “Specification for Structural Steel Buildings--Allowable Stress Design and Plastic Design.”

4. AISC “Specification for the Design of Steel Hollow Structural Sections.”

5. AISC “Specification for Allowable Stress Design of Single-Angle Members”.

6. RCSC “Specifications for Structural Joints Using ASTM A 325 or A 490 Bolts.”

1.5 Delivery, Storage, and Handling

A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from erosion and deterioration.

1. Store fasteners in a protected place. Re-lubricate bolts and nuts that become dry.

2. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.

3. Do not clean and use rusty bolts.

1.6 Coordination

A. Furnish anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

Part 2 Products

2.1 Structural-Steel Materials

A. W-Shapes: ASTM A 992.

B. Channels, Angles, and Shapes: ASTM A 36 unless otherwise noted.

C. Plate and Bar: ASTM A 36 unless otherwise noted.

D. Cold-Formed Hollow Structural Sections: ASTM A 500, Grade B structural tubing.

E. Steel Pipe: ASTM A53, Type E or S, Grade B.

1. Weight Class: Standard unless otherwise indicated.

2. Finish: Black, except where indicated to be galvanized.

F. Welding Electrodes: Comply with AWS requirements. Tensile strength should be the same or greater than base metal.

2.2 Bolts, Connectors, and Anchors

A. High-Strength Bolts, Nuts, and Washers: ASTM A 325 Type 1, heavy hex steel structural bolts; ASTM A 563 heavy hex carbon steel nuts; and ASTM F 436 hardened carbon-steel washers.

1. Finish: Plain unless noted or indicated otherwise.

B. Headed and Un-headed Anchor Rods: ASTM F 1554, Grade 36, unless otherwise indicated.

1. Configuration: as indicated.

2. Nuts: ASTM A 563, heavy hex carbon steel.

3. Plate Washers: ASTM A 36 carbon steel.

4. Washers: ASTM F 436, hardened carbon steel.

5. Finish: Plain, unless noted or indicated otherwise.

C. Threaded Rods: ASTM A 36.

1. Nuts: ASTM A 563 heavy hex carbon steel.

2. Washers: ASTM F 436 hardened carbon steel.

3. Finish: Plain, unless noted or indicated otherwise.

D. Clevises or turnbuckles: ASTM A 108, Grade 1035, cold-finished carbon steel.

E. Eye Bolts and Nuts: ASTM A 108, Grade 1030, cold-finished carbon steel.

F. Sleeve Nuts: ASTM A 108, Grade 1018, cold-finished carbon steel.

2.3 Primer

A. Primer: Fabricator’s standard lead and chromate free non-asphaltic rust inhibiting primer.

B. Galvanizing Repair Paint: MPI#18, MPI#19, or SSPC-Paint 20.

2.4 Fabrication

A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC “Code of Standard Practice for Steel Buildings and Bridges” and AISC “Specification for Structural Steel Buildings--Allowable Stress Design and Plastic Design”.

1. Camber structural-steel members where indicated.

2. Identify high-strength structural steel according to ASTM A 6 and maintain markings until structural steel has been erected.

3. Mark and match-mark materials for field assembly.

4. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.

B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.

1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1.

C. Bolt Holes: Cut, drill, or punch standard bolt holes perpendicular to metal surfaces.

D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.

E. Cleaning: Clean and prepare steel surfaces that are to remain unpainted according to SSPC-SP 3, “Power Tool Cleaning.”

F. Steel Wall-Opening Framing: Select true and straight members for fabricating steel wall-opening framing to be attached to structural steel. Straighten as required to provide uniform, square, and true members in completed wall framing.

G. Welded Door Frames: Build up welded door frames attached to structural steel. Weld exposed joints continuously and grind smooth. Plug-weld fixed steel bar stops to frames. Secure removable stops to frames with countersunk, cross-recessed head machine screws, uniformly spaced not more than 10” o.c., unless otherwise indicated.

H. Holes: Provide holes required for securing other work to structural steel and for passage of other work through steel framing members.

1. Cut, drill, or punch holes perpendicular to steel surfaces.

2. Base-Plate Holes: Cut, drill, or punch holes perpendicular to steel surfaces.

3. Weld threaded nuts to framing and other specialty items indicated to receive other work.

2.5 Shop Connections

A. High-Strength Bolts: Shop install high-strength bolts according to RCSC “Specification for Structural Joints Using ASTM A 325 or A 490 Bolts” for type of bolt and type of joint specified.

1. Joint Type: Snug tightened.

B. Weld Connections: Comply with AWS D1.1 for welding procedure specifications, tolerances, appearance, and quality of welds and for methods used in correcting welding work.

1. Remove backing bars or runoff tabs, back gouge, and grind steel smooth.

2. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances of AISC “Code of Standard Practice for Steel Buildings and Bridges” for mill material.

2.6 Shop Priming

A. Shop prime steel surfaces except the following:

1. Surfaces to be field welded.

2. Surfaces to be high-strength bolted with slip-critical connections.

3. Surfaces to receive sprayed fire-resistive materials.

4. Galvanized surfaces.

B. Surface Preparation: Clean the surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:

1. SSPC-SP 3, “Power Tool Cleaning.”

C. Priming: Immediately after surface preparation, apply primer according to Manufacturer’s written instructions and at rate recommended by SSPC to provide a dry film thickness of not less than 1.5 mils. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

1. Stripe paint corners, crevices, bolts, welds, and sharp edges.

2. Apply two coats of shop paint to inaccessible surfaces after assembly or erection. Change color of second coat to distinguish it from first.

D. Painting: Apply a 1-coat, non-asphaltic primer complying with SSPC-PS Guide 7.00, “Painting System Guide 7.00: Guide for Selecting One-Coat Shop Painting Systems,” to provide a dry film thickness of not less than 1.5 mils.

2.7 Galvanizing

A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A 123.

1. Fill vent holes and grind smooth after galvanizing.

2. Galvanize lintels and shelf angles attached to structural-steel frame and located in exterior walls.

Part 3 Execution

3.1 Examination

A. Verify elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedment, with steel erector present, for compliance with requirements.

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

3.2 Preparation

A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place, unless otherwise indicated.

1. Do not remove temporary shoring supporting composite deck construction until cast-in-place concrete has attained its design compressive strength.

3.3 Erection

A. Set structural steel accurately in locations and to elevations indicated and according to AISC “Code of Standard Practice for Steel Buildings and Bridges” and “Specification for Structural Steel Buildings--Allowable Stress Design and Plastic Design”.

B. Base and Bearing Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials and roughen surfaces prior to setting base and bearing plates. Clean bottom surface of base and bearing plates.

1. Set base and bearing plates for structural members on wedges, shims, or setting nuts as required.

2. Weld plate washers to top of base plate.

3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of base or bearing plate before packing with grout.

4. Promptly pack grout solidly between bearing surfaces and base or bearing plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow it to cure. Comply with Manufacturer’s written installation instructions for shrinkage-resistant grouts.

C. Maintain erection tolerances of structural steel within AISC “Code of Standard Practice for Steel Buildings and Bridges.”

D. Align and adjust various members forming part of complete frame or structure before permanently fastening. Before assembly clean bearing surfaces and other surfaces that will be in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

1. Level and plumb individual members of structure.

2. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.

E. Splice members only where indicated.

F. Do not use thermal cutting during erection unless approved by Engineer. Finish thermally cut sections within smoothness limits in AWS D1.1.

G. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.

3.4 Field Connections

A. High-Strength Bolts: Install high-strength bolts according to RCSC “Specification for Structural Joints Using ASTM A 325 or A 490 Bolts” for type of bolt and type of joint specified.

1. Joint Type: Snug tightened, unless noted or indicated otherwise.

2. Acceptable Thread Engagement: All threaded connections shall have a minimum of 3 threads exposed to be considered acceptable by the inspector. Less than three threads may be considered acceptable if secured with a tack weld and if this deems to be an appropriate resolution.

B. Weld Connections: Comply with AWS D1.1 for welding procedure specifications, tolerances, appearance, and quality of welds and for methods used in correcting welding work.

1. Comply with AISC “Code of Standard Practice for Steel Buildings and Bridges” and “Specification for Structural Steel Buildings--Allowable Stress Design and Plastic Design”, for bearing, adequacy of temporary connections, alignment, and removal of paint on surfaces adjacent to field welds.

2. Remove backing bars or runoff tabs, back gouge, and grind steel smooth.

3. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances of AISC “Code of Standard Practice for Steel Buildings and Bridges” for mill material.

3.5 Field Quality Control

A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to inspect field welds and high-strength bolted connections.

B. Bolted Connections: Shop-bolted connections will be tested and inspected according to RCSC “Specification for Structural Joints Using ASTM A 325 or A 490 Bolts.”

C. Welded Connections: Field welds will be visually inspected according to AWS D1.1.

D. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.

3.6 Repairs and Protection

A. Repair damaged galvanized coatings on galvanized items with galvanized repair paint according to ASTM A 780 and Manufacturer’s written instructions.

B. Touchup Painting: After installation, promptly clean, prepare, and prime or re-prime field connections, rust spots, and abraded surfaces of prime-painted joists and accessories, bearing plates, and abutting structural steel.

1. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning.

2. Apply a compatible primer of same type as shop primer used on adjacent surfaces.

C. Touchup Painting: Cleaning and touchup painting are specified in Section 09 90 15 - Paint.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Steel framing and supports for overhead doors.
2. Steel framing and supports for mechanical and electrical equipment.
3. Steel framing and supports for applications where framing and supports are not specified in other Sections.
4. Shelf angles.
5. Loose bearing and leveling plates.
6. Steel welded plates and angles for casting into concrete not specified in other Sections.
7. Miscellaneous steel trim including steel angle corner guards and steel edgings.
8. Metal ladders.
9. Metal bollards.
10. Pipe guards.
11. Metal floor plate and supports.
12. Abrasive metal nosing, treads, and thresholds.

B. Products furnished, but not installed, under this Section include the following:

1. Loose steel lintels.
2. Anchor bolts, steel pipe sleeves, and wedge-type inserts indicated to be cast into concrete or built into unit masonry.

C. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.

3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.

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

   b. Section 05 12 00 - Structural Steel.

   c. Section 05 52 13 - Pipe and Tube Railings.

   d. Section 05 53 00 - Metal Gratings.

   e. Section 07 92 00 – Sealants and Caulking.

1.2 Performance Requirements

A. Structural Performance of Ladders: Provide ladders capable of withstanding the effects of loads and stresses within limits and under conditions specified in ANSI A14.3.

B. Thermal Movements: Provide exterior metal fabrications that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

   1. Temperature Change (Range): 120 °F, ambient; 180 °F, material surfaces.

1.3 Submittals

A. Product Data: For the following:

   1. All miscellaneous metals required for the work.

   2. Paint products required as a part of the work for this section.

   3. Concrete anchors.

B. Shop Drawings: Show fabrication and installation details for metal fabrications.

   1. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items.

   2. Provide templates for anchors and bolts specified for installation under other Sections.

   3. For installed products which are indicated as a delegated design item, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Samples for Verification: For each type and finish of extruded nosing and tread.

D. Mill Certificates: Signed by Manufacturers of stainless-steel sheet certifying that products furnished comply with requirements.

E. Welding certificates.

1.4 Quality Assurance

A. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1, “Structural Welding Code--Steel.”
2. AWS D1.2, “Structural Welding Code--Aluminum.”
3. AWS D1.3, “Structural Welding Code--Sheet Steel.”
4. AWS D1.6, “Structural Welding Code--Stainless Steel.”

1.5 Project Conditions

A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication and indicate measurements on Shop Drawings.

1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating metal fabrications without field measurements. Coordinate wall and other contiguous construction to ensure that actual dimensions correspond to established dimensions.
2. Provide allowance for trimming and fitting at site.

1.6 Coordination

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

B. Coordinate installation of steel weld plates and angles for casting into concrete that are specified in this Section but required for work of another Section. Deliver such items to Project site in time for installation.

Part 2 Products

2.1 Manufacturers

A. In other Part 2 Articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.

2. Available Manufacturers: Subject to compliance with requirements, Manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 Metals, General

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces, unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

B. Ferrous Metals

1. Steel Plates, Shapes, and Bars: ASTM A 36.

2. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A 666, Type 304 or 316.

3. Stainless-Steel Bars and Shapes: ASTM A 276, Type 304 or 316.

4. Steel Tubing: ASTM A 500, cold-formed steel tubing.

5. Steel Pipe: ASTM A 53, standard weight (Schedule 40), unless another weight is indicated or required by structural loads.

6. Cast Iron: ASTM A 48, Class 30, unless another class is indicated or required by structural loads.

C. Nonferrous Metals

1. Aluminum Plate and Sheet: ASTM B 209, Alloy 6061-T6.

2. Aluminum Extrusions: ASTM B 221, Alloy 6061-T6.

3. Aluminum-Alloy Rolled Tread Plate: ASTM B 632, Alloy 6061-T6.

4. Aluminum Castings: ASTM B 26, Alloy 443.0-F.

2.3 Fasteners

A. General: Unless otherwise indicated, provide Type 304 or 316 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633, Class Fe/Zn5, at exterior walls. Provide stainless-steel fasteners for fastening aluminum. Select fasteners for type, grade, and class required.

B. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A, with hex nuts, ASTM A 563; and, where indicated, flat washers.

1. Finish: Plain or Hot Dip Zinc-coated ASTM A153 Class C, as indicated.

C. Stainless-Steel Bolts and Nuts: Regular hexagon-head annealed stainless-steel bolts, nuts and, where indicated, flat washers; ASTM F 593, AISI Type 316, Condition CW for bolts an ASTM F 594 for AISI Type 316, Condition CW nuts.

1. All threads on stainless steel rods/bolts shall be protected with anti-seize lubricant suitable for submerged stainless bolts and complying with Federal Specification MIL-A-907E.

D. Anchor Bolts: ASTM F 1554, Grade 36, unless noted otherwise on the drawings.

1. Provide hot-dip or mechanically deposited, zinc-coated anchor bolts where item being fastened is indicated to be galvanized.

E. Machine Screws: ASME B 18.6.3.

F. Lag Bolts: ASME B 18.2.1.

G. Wood Screws: Flat head, ASME B18.6.1.

H. Plain Washers: Round, ASME B 18.22.1.

I. Lock Washers: Helical, spring type, ASME B 18.21.1.

J. Cast-in-Place Anchor Rods: Anchors capable of sustaining, without failure, a load equal to four times the load imposed, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.

1. ASTM F1554 (grade as indicated on the drawings) threaded or wedge type; galvanized ferrous castings either ASTM A 47 malleable iron or ASTM A 27, cast steel. Provide bolts, washers, and shims as needed, hot-dip galvanized per ASTM A 153.

K. Expansion Anchors: Anchor bolt and sleeve assembly with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.

1. Basis of Design equal to: Hilti Kwik Bolt TZ

   a. If the contractor chooses to submit an anchor other than that listed as the basis of design, then the contractor is responsible for providing adequate documentation to prove that the submitted anchor meets or exceeds the design capacity of the anchor specified and is ICC certified.

2. Material for Anchors in Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B 633, Class Fe/Zn 5.

3. Material for Anchors in Exterior Locations: ASTM F 593, AISI Type 316, Condition CW for bolts and ASTM F 594 for AISI Type 316, Condition CW nuts.

4. Expansion anchors shall not be substituted for adhesive anchors.

L. Adhesive Anchors:

1. Threaded Rod:

   a. ASTM F 593 stainless steel threaded rod, diameter as shown on Drawings.

   b. Length as required to provide minimum depth of embedment.

   c. Clean and fee of grease, oil, or other deleterious material.

   d. For hollow-unit masonry, provide galvanized or stainless steel wire cloth screen tube to fit threaded rod.

2. Adhesive:

   a. Basis of Design equal to: Hilti HIT-HY 200

      1) If the contractor chooses to submit an anchor other than that listed as the basis of design, then the contractor is responsible for providing adequate documentation to prove that the submitted anchor meets or exceeds the design capacity of the anchor specified and is ICC certified.

   b. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments, with gray color after mixing.

   c. Cure Temperature, Pot Life, and Workability: Compatible for intended use and environmental conditions.

   d. Non-sag, with selected viscosity based on installation temperature and overhead application where applicable.

3. Packaging:

    a. Disposable, self-contained cartridge system capable of dispensing both components in the proper mixing ratio and fitting into a manually or pneumatically operated caulking gun.

    b. Cartridge Marking: Include manufacturer’s name, product name, material type, batch serial number, and adhesive expiration date.

2.4 Miscellaneous Materials

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Shop Primers: Provide primers that comply with Division 9.

C. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79.

    1. Use primer with a VOC content of 420 g/L (3.5 lb/gal.), or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

    2. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.

D. Zinc-Rich Primer: Complying with SSPC-Paint 20 or SSPC-Paint 29 and compatible with topcoat specified in Section 09 90 15.

    1. Use primer with a VOC content of 420 g/L (3.5 lb/gal.), or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Galvanizing Repair Paint: High-zinc-dust-content paint for re-galvanizing welds in steel, complying with SSPC-Paint 20.

F. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.5 Fabrication, General

A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32”, unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

D. Form exposed work true to line and level with accurate angles and surfaces and straight edges.

E. Weld corners and seams continuously to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) screws or bolts, unless otherwise indicated. Locate joints where least conspicuous.

G. Fabricate seams and other connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.

I. Provide for anchorage of type indicated; coordinate with supporting structure, and space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.

2.6 Miscellaneous Framing and Supports

A. General: Design and provide steel framing and supports not specified in other Sections as needed to complete the Work.

B. Fabricate units from steel shapes, plates, and bars of welded construction, unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction retained by framing and supports. Cut, drill, and tap units to receive hardware, hangers, and similar items.

1. Fabricate units from slotted channel framing where indicated.

2. Furnish inserts if units are installed after concrete is placed.

C. Galvanize miscellaneous framing and supports where indicated.

D. Prime miscellaneous framing and supports with zinc-rich primer where indicated.

2.7 Loose Steel Lintel

A. Fabricate loose steel lintels from steel angles and shapes of size indicated for openings and recesses in masonry walls and partitions at locations indicated. Weld adjoining members together to form a single unit where indicated.

B. Size loose lintels to provide bearing length at each side of openings equal to 1/12 of clear span but not less than 8”, unless otherwise indicated.

C. Provide galvanized loose steel lintels located in exterior walls.

D. Prime loose steel lintels located in interior walls with zinc-rich primer.

2.8 Loose Bearing and Leveling Plates

A. Provide loose bearing and leveling plates for steel items bearing on masonry or concrete construction. Drill plates to receive anchor bolts and for grouting.

B. Galvanize plates after fabrication.

C. Prime plates with zinc-rich primer.

2.9 Steel Weld Plates and Angles

A. Provide steel weld plates and angles not specified in other Sections, for items supported from concrete construction as needed to complete the Work. Provide each unit with not less than two integrally welded steel strap anchors for embedding in concrete.

2.10 Miscellaneous Steel Trim

A. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.

B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work.

1. Provide with integrally welded steel strap anchors for embedding in concrete or masonry construction.

C. Galvanize exterior miscellaneous steel trim.

D. Prime interior miscellaneous steel trim, with zinc-rich primer.

2.11 Metal Ladders

A. General:

1. Comply with the more stringent requirements of OSHA and ANSI A14.3, unless indicated otherwise.

2. Space side rails 18” clear minimum, unless otherwise indicated.

3. Support each ladder at top and bottom and not more than 60 inches o.c, with welded or bolted brackets, made from same metal as ladder.

4. All ladders, including ladders less than 20 feet in height, shall be equipped with an integral fall protection system.

B. Extension (Pop-up). Every ladder that does not have an exterior hand hold shall be equipped with a pop-up extension designed by the ladder manufacturer.

1. Pop-up extension shall be of the same material and finish as the ladder with telescoping tubular section that locks automatically when fully extended.

2. Upward and downward movement shall be controlled by stainless steel spring balancing mechanisms.

3. Units shall be completely assembled with fasteners for securing to the ladder rungs in accordance with the manufacturer’s recommendations.

C. Fall Prevention System (Ladder):

1. All ladders, including ladders less than 20 feet in height, shall be equipped with an integral fall prevention system. The fall prevention system at each ladder shall include a permanent metal carrier rung/rail, carrier rung/rail extension as required, sliding sleeve arresting unit, ladder rung clamps, full body harness, dismount section and all other components as necessary for complete installation and system to comply with OSHA and ANSI A14.3 standards and requirements.

a. The fall prevention system manufacturer shall design each fall prevention system, coordinate with the ladder manufacturer and submit the fall prevention system design and detailed plans to the Engineer for approval.

b. The carrier rung/rail shall be Type 316 stainless steel or aluminum alloy 6105-T5.

c. Carrier rung/rail extensions shall be provided for safe ladder access and egress. The total carrier rung/rail length shall be as designed by the fall prevention system manufacturer.

d. Manufacturers equal to:

1) Sellstorm Manufacturing.

2) North Safety Products, Ltd.

D. Steel Ladders:

1. Fit rungs in centerline of side rails; plug-weld and grind smooth on outer rail faces.

2. Rung spacing shall not exceed 12 inches on center.

3. Provide non-slip surfaces on top of each rung by coating with abrasive material metallically bonded to rung by a proprietary process.

4. Products equal to:

   a. IKG Industries, a Harsco company; Mebac.

   b. W. S. Molnar Company; SlipNOT.

5. Galvanize exterior ladders and interior ladders, unless indicated otherwise, including brackets and fasteners.

E. Aluminum Ladders:

1. Fit rungs in centerline of side rails; fasten by welding or with stainless-steel fasteners or brackets and aluminum rivets.

2. Rung spacing shall not exceed 12 inches on center.

3. Provide non-slip surfaces on top of each rung by coating with abrasive material metallically bonded to rung by a proprietary process.

4. Products equal to:

   a. IKG Industries, a Harsco company; Mebac.

   b. W. S. Molnar Company; SlipNOT.

2.12 Metal Floor Plate

A. Also referenced as “Checkered” or “Check” Plate, with raised lugs on one side and smooth surface on other side.

B. Fabricate from roller-aluminum-alloy 6061-T6, ASTM B 632 plate of thickness indicated below. Raised lug pattern shall be on top and start at 45° angle to edge of plate or tread.

C. Provide stainless steel or aluminum angle stiffeners and/or aluminum beam supports, as indicated or required.

D. Provide flush stainless steel bar drop handles for lifting removable sections. Provide one at each end of each section.

E. All ends and openings shall be banded and sealed with a 1/4-inch neoprene gasket.

F. The weight of a floor plate section shall not exceed 150 pounds.

G. Aluminum surfaces in contact with concrete, grout or dissimilar metals will be protected with a coat of bituminous paint, Mylar isolators or other protective system, as approved by the Engineer.

H. Manufacturers equal to:

1. Thompson Fabricating, LLC; Tarrant, AL.

2.13 Metal Bollards

A. Fabricate metal bollards from 6” diameter steel pipe and fill with non-structural concrete. Refer to drawings and standard details for locations and anchorage details.

B. Paint exposed portions of pipe with an OSHA safety yellow paint.

2.14 Abrasive Metal Nosings and Treads

A. Cast-Metal Units: Cast aluminum, with an integral abrasive finish consisting of aluminum oxide, silicon carbide, or a combination of both. Fabricate units in sizes and configurations indicated and in lengths necessary to accurately fit openings or conditions.

1. Manufacturers equal to:

    a. American Safety Tread Co., Inc.

    b. Baleo Inc.

    c. Barry Pattern & Foundry Co., Inc.

    d. Granite State Casting Co.

    e. Safe-T-Metal Co.

    f. Wooster Products Inc.

2. Nosing: Cross-hatched units, 4 inches wide with ¼ inch lip, for casting into concrete steps.

3. Nosing: Cross-hatched units, 1-1/2 inch by 1-1/2 inch, for casting into concrete curbs.

4. Treads: Cross-hatched units, full depth of tread with 3/4inch by 3/4inch nosing, for application over bent plate treads or existing stairs.

B. Extruded Units: Aluminum, with abrasive filler consisting of aluminum oxide, silicon carbide, or a combination of both, in an epoxy-resin binder. Fabricate units in sizes and configurations indicated and in lengths necessary to accurately fit openings or conditions.

1. Manufacturers equal to:

    a. ACL Industries, Inc.

    b. American Safety Tread Co., Inc.

    c. Amstep Products.

    d. Armstrong Products, Inc.

e. Baleo Inc.

f. Granite State Casting Co.

g. Wooster Products Inc.

2. Provide ribbed units, with abrasive filler strips projecting 1/16 inch above aluminum extrusion.

3. Provide solid-abrasive-type units without ribs.

4. Nosing: Square-back units, 3 inches wide, for casting into concrete steps.

5. Nosing: Beveled-back units, 3 inches wide with 1-3/8 inch lip, for surface mounting on existing stairs.

6. Nosing: Two-piece units, 3 inches wide, with sub channel for casting into concrete steps.

7. Treads: Beveled-back units, full depth of tread with 1-3/8 inch lip, for application over existing stairs.

C. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with Manufacturer.

D. Drill for mechanical anchors and countersink. Locate not more than 4 inches from ends and not more than 12 inches o.c., evenly spaced between ends, unless otherwise indicated. Provide closer spacing if recommended by Manufacturer.

1. Provide 2 rows of holes for units more than 5 inches wide, with 2 holes aligned at ends and intermediate holes staggered.

E. Apply bituminous paint, Mylar isolators or other protective system as approved by the Engineer to concealed bottoms, sides, and edges of cast-metal units set into concrete

2.15 Finishes, General

A. Comply with NAAMM “Metal Finishes Manual for Architectural and Metal Products” for recommendations for applying and designating finishes.

B. Finish metal fabrications after assembly according to the paintings and protective coatings specification.

2.16 Steel and Iron Finishes

A. Galvanizing: Hot-dip galvanize items as indicated to comply with applicable standard listed below:

1. ASTM A 123 for galvanizing steel and iron products.

2. ASTM A 153 for galvanizing steel and iron hardware.

B. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface preparation specifications and environmental exposure conditions of installed metal fabrications:

1. Exteriors (SSPC Zone 1B) and Items Indicated to Receive Zinc-Rich primer: SP 6/NACE

C. No.3, “Commercial Blast Cleaning.”

1. 2. Interiors (SSPC Zone 1A): SSPC-SP 3, “Power Tool Cleaning.”

D. Shop Priming: Apply shop primer to uncoated surfaces of metal fabrications, except those with galvanized finishes and those to be embedded in concrete, sprayed-on fireproofing, or masonry, unless otherwise indicated. Comply with SSPC-PA 1, “Paint Application Specification No.1: Shop, Field, and Maintenance Painting of Steel,” for shop painting.

1. Stripe paint corners, crevices, bolts, welds, and sharp edges.

2.17 Stainless-Steel Finishes

A. Remove tool and die marks and stretch lines or blend into finish.

B. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

C. Bright, Directional Satin Finish: No.4.

D. Dull Satin Finish: No.6.

E. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

Part 3 Execution

3.1 Installation, General

A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.

B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

C. Field Welding: Comply with the following requirements:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag bolts, wood screws, and other connectors.

E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

F. Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals with a heavy coat of bituminous paint.

3.2 Installing Miscellaneous Framing and Supports

A. General: Install framing and supports to comply with requirements of items being supported, including Manufacturers' written instructions and requirements indicated on Shop Drawings.

B. Install pipe columns on concrete footings with grouted baseplates. Position and grout column baseplates as specified in "Installing Bearing and Leveling Plates" Article.

3.3 Installing Bearing and Leveling Plates

A. Clean concrete and masonry bearing surfaces of bond-reducing materials and roughen to improve bond to surfaces. Clean bottom surface of plates.

B. Set bearing and leveling plates on wedges, shims, or leveling nuts. After bearing members have been positioned and plumbed, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with grout.

1. Use non-shrink grout, nonmetallic, in concealed locations where not exposed to moisture; use non-shrink, nonmetallic grout in exposed locations, unless otherwise indicated.

2. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

3.4 Installing Metal Bollards

A. Anchor bollards in concrete as indicated on the drawings.

B. Anchor bollards in place with non-structural concrete, as indicated on the drawings. Place concrete and vibrate or tamp for consolidation. Support and brace bollards in position until concrete has cured.

C. Fill bollards solidly with concrete, mounding top surface to shed water.

1. Do not fill removable bollards with concrete.

3.5 Installing Nosings, Treads, and Thresholds

A. Center nosing on tread widths.

B. For nosing embedded in concrete steps or curbs, align nosing flush with riser faces and level with tread surfaces.

C. Seal thresholds exposed to exterior with elastomeric sealant complying with Section 07 92 00 – Sealants and Caulking to provide a watertight installation.

3.6 Adjusting and Cleaning

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

1. Apply by brush or spray to provide a minimum 2.0 mil dry film thickness.

B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Division 9 painting Sections.

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

END OF SECTION

Part 1 General

1.1 Section Includes

A. Clean and prepare joint surfaces.

B. Sealant and backing materials.

1.2 Submittals

A. Submit under provisions of Section 01 33 00.

B. Product Data: Provide data on sealant materials, characteristics and required surface preparation.

C. Samples: Submit samples of sealant colors.

D. Manufacturer's Installation Instructions: Indicate preparation required, installation techniques and other applicable requirements.

1.3 Warranty

A. Provide 5-year warranty under provisions of Section 01 78 36.

B. Warranty: Replace sealants which fail because of loss of cohesion or adhesion, or do not cure.

Part 2 Products

2.1 Acceptable Manufacturers

A. Dow Corning.

B. Sika Corp.

C. Tremco, Inc.

D. Substitutions: Under provisions of Section 01 25 00.

2.2 Sealant Materials

A. Acrylic Emulsion Latex (Type A): ASTM C834, single component; color as selected.

B. Silicone Sealant (Type D): ASTM C920, Grade NS, Class 25, single component, fungus resistant, chemical curing, non-sagging, non-staining, non-bleeding; color as selected; 790 manufactured by Dow Corning.

C. Silicone Sealant (Type E): ASTM C920, Grade NS, Class 25, single component, fungus resistant, non-sagging, non-staining, non-bleeding; color as selected; 799 manufactured by Dow Corning.

D. Acoustic Sealant: Non-hardening with a durometer of 35, by U.S. Gypsum, Tremco, or Protective Treatments, Inc.

2.3 Accessories

A. Primer: Non-staining type, recommended by sealant manufacturer to suit application.

B. Joint Cleaner: Non-corrosive and non-staining type, recommended by sealant manufacturer; compatible with joint forming materials.

C. Joint Filler: ASTM D1056; round, closed cell polyethylene foam rod; oversized 30 to 50 percent.

D. Bond Breaker: Pressure sensitive tape recommended by sealant manufacturer to suit application.

Part 3 Execution

3.1 Inspection

A. Verify joint dimensions, physical, and environmental conditions are acceptable to receive work of this Section.

B. Beginning of installation means acceptance.

3.2 Preparation

A. Clean, prepare, and size joints in accordance with manufacturer's instructions. Remove any loose materials and other foreign matter which might impair adhesion of sealant.

B. Verify that joint shaping materials and release tapes are compatible with sealant.

C. Examine joint dimensions and size materials to achieve required width/depth ratios.

D. Use joint filler to achieve required joint depths, to allow sealants to perform properly.

E. Use bond breaker where required.

3.3 Installation

A. Perform work in accordance with ASTM C804 for solvent release sealants.

B. Install sealant in accordance with manufacturer's instructions.

C. Apply sealant within recommended temperature ranges. Consult manufacturer when sealant cannot be applied within recommended temperature ranges.

D. Tool joints concave.

E. Joints: Free of air pockets, foreign embedded matter, ridges, and sags.

3.4 Schedule

A. Exterior Wood or Metal: Type D: color selected to match finish color.

B. Masonry Walls: Type D; color as selected to match face brick. Change color of vertical joint sealants at accent brick colors.

C. Flashing and Sheet Metal: Type D; color as selected to match finish.

D. Bedding Joints (Sills, thresholds, etc.): Type E; color - clear.

E. Interior Joints Not Subject to Movement (door and window frames, countertops, etc.): Type A, color - white for paint finish or clear for exposed applications.

END OF SECTION

Part 1 General

1.1 Summary

A. Fabrication and installation of cast-in-place, floor access doors and hatches.

B. Equipment shall be furnished complete with all components and accessories required for proper operation, and any additional materials or construction required by the manufacturer's design. Fabricated items which are indicated on the Drawings but not mentioned specifically herein shall be fabricated in accordance with the applicable requirements of this section.

C. Floor door opening sizes, number and swing direction of leaves, and locations, shall be as indicated on the Drawings.

1. Furnish all equipment as shown on the Drawings and as specified herein.

1.2 Quality Assurance

A. All floor doors furnished under this Section shall be of a design and manufacture that has been used in similar applications and it shall be demonstrated to the satisfaction of the Owner that the quality is equal to equipment made by the manufacturer specifically named herein.

1. Manufacturer: A minimum of 5 years' experience manufacturing similar products.

2. Installer: A minimum of 2 years' experience manufacturing similar products.

B. Unit Responsibility: Floor doors, complete with frame and all other specified accessories and appurtenances, shall be furnished by the floor door manufacturer to ensure compatibility and integrity of the individual components and provide the specified warranty for all components.

C. The floor doors specified in this Section, complete with frame and all other specified accessories and appurtenances, shall be furnished by and be the product of one manufacturer.

1.3 Submittals

A. Submit information to establish compliance with the Specifications in accordance with the provisions of Section 01 33 00 - Submittal Procedures.

B. Submit floor door location, identification number and specification number.

C. Submit drawing plan and cross sections of equipment.

D. Shop Drawings:

1. Complete assembly and installation Drawings

E. Product Data:

1. Detailed specifications

2. Capacities

3. Material used

4. Accessories

F. Detailed list of any exceptions taken to these Specifications. Include specification reference and proposed alternative with reason stated for exception.

1.4 Warranty

A. The manufacturer shall guarantee against defects in material or workmanship for a warranty period of not less than 5 years.

Part 2 Products

2.1 Manufacturers

A. The Bilco Company

B. Halliday Product

C. Thompson Fabricating, LLC

2.2 General

A. Access doors and hatches shall be fabricated in conformity with dimensions, arrangements, sizes, and weights or thicknesses specified herein and as indicated on the Drawings. All members and parts shall be free of warps, local deformations, and unauthorized bends. Holes and other provisions for field connections shall be accurately located and shop checked so that proper fit will result when the units are assembled in the field. All field connection materials shall be furnished.

2.3 Channel Frame Gasketed Covers

A. The single leaf access frames and covers shall have a ¼ inch (7mm) thick one-piece, mill finish, extruded aluminum channel frame, incorporating a continuous concrete anchor. A 1-1/2 inch (38mm) drainage coupling shall be located in the corner of the channel frame, A bituminous coating shall be applied to the frame exterior where it will come in contact with concrete. Door panel shall be ¼ inch (7mm) aluminum diamond plate, reinforced to withstand a live load of 300 lbs. psf (1464 kg. psm). Door shall open to 90 degrees and automatically lock with a T-316 stainless steel hold open arm with an aluminum release handle. For ease of operation, the hold open arm shall incorporate an enclosed stainless steel compression spring as-

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sist. Doors shall close flush with the frame and rest on a built-in neoprene gasket to ensure odor resistance. The gasket shall limit air infiltration to less than 1 cfm. per lineal foot of opening perimeter with a pressure differential equal to a 1 inch column of water. Hinges and all fastening hardware shall be T-316 stainless steel. Unit shall lock with a T-316 stainless steel slam lock with removable key and have a non-corrosive handle. Unit shall carry a lifetime guarantee against defects in material and/or workmanship.

B. The double leaf access frames and covers shall have a ¼ inch (7 mm) thick one-piece, mill finish, extruded aluminum channel frame, incorporating a continuous concrete anchor. A 1-1/2 inch (38 mm) drainage coupling shall be located in the corner of the channel frame. A bituminous coating shall be applied to the frame exterior where it will come in contact with concrete. Door panel shall be ¼ inch (7mm) aluminum diamond plate, reinforced to withstand a live load of 30 lbs. psf (1464 kg. psm), uniform live load. Door shall open to 90 degrees and automatically lock with a T-316 stainless steel hold open arm with an aluminum release handle. For ease of operation, the hold open arm shall incorporate an enclosed stainless steel compression spring assist. Doors shall close flush with the frame and rest on a built-in neoprene cushion/gasket. Hinges and all fastening hardware shall be T-316 stainless steel. Unit shall lock with a T-316 stainless steel slam lock with removable key and have a non-corrosive handle. Unit shall carry a lifetime guarantee against defects in material and/or workmanship.

C. Provide fall protection safety system. The protective grating panel shall be 1 inch (25 kg.) aluminum “I” bar grating with Safety Yellow powder-coated finish. Grating shall be hinged with tamper proof stainless steel bolts, and shall be supplied with a positive latch to maintain unit in an upright position. Grating shall have a 6 inch (152 mm) viewing area on each lateral unhinged side for visual observation and limited maintenance. Grating support ledges on 300 lbs. psf (1464 kg. per sq. meter) loaded access covers shall incorporate nut rail with a minimum of four (4) stainless steel spring nuts for mounting pump brackets and/or cable holders. A padlock hasp for owner-supplied padlock shall be provided.

Part 3 Execution

3.1 Installation Procedure

A. Follow equipment manufacturer’s recommendations for equipment installation and as follows.

B. Fasteners and Anchors to Concrete

1. Expansion and wedge anchors shall not be allowed.

2. All fasteners and anchors which are not integrally cast within the concrete shall be adhesive anchor systems.

3. Adhesive Anchor System: Refer to section 05 50 00 - Metal Fabrications for requirements.

C. All threads on stainless steel rods/bolts shall be protected with an anti-seize lubricant suitable for submerged stainless bolts and complying with Federal Specification MILI-A-907E.

END OF SECTION

Part 1 General

1.1 Work Included

A. Surface preparation.

B. Field application of paints and other coatings.

C. Scope: Finish all interior and exterior surfaces exposed to view, unless fully factory-finished and unless otherwise indicated, including the following:

1. Mechanical and Electrical:

   a. In finished areas, paint all insulated and exposed pipes, conduit, boxes, insulated and exposed ducts, hangers, brackets, collars and supports, mechanical equipment, and electrical equipment, unless otherwise indicated.

   b. In finished areas, paint shop-primed items.

D. Do Not Paint or Finish the Following Items:

1. Items fully factory-finished unless specifically so indicated; materials and products having factory-applied primers are not considered factory finished.
2. Items indicated to receive other finishes.
3. Items indicated to remain unfinished.
4. Fire rating labels, equipment serial number and capacity labels, and operating parts of equipment.
5. Stainless steel, anodized aluminum, bronze, terne, and lead items.
6. Floors, unless specifically so indicated.
7. Glass.
8. Concrete masonry in utility, mechanical, and electrical spaces.
9. Concealed pipes, ducts, and conduits.
10. Operating parts or machined surfaces.

1.2 Definitions

A. Conform to ASTM D16 for interpretation of terms used in this section.

1.3 Submittals

A. See Section 01 33 00 – Submittal Procedures for submittal procedures.

B. Product Data: Provide data on all finishing products, including VOC content.

C. Samples: Submit two paper chip samples, 3" x 5" inch (76.2 x 127 mm) in size illustrating range of colors and textures available for each surface finishing product scheduled.

D. Paint Schedule: Provide list, by process area or building, of all surfaces to be coated, with selected coating system identified. Where required colors are identified in other Sections, provide color chart and identify required colors on paint schedule. Where required colors are not identified, leave space for Owner to provide selected color.

E. Piping Identification layout and colors.

F. Certificates

1. Applicator's Qualifications.

2. Qualification Testing laboratory for coatings.

3. Indoor Air Quality data for Paints and Primers.

a. For occupied indoor spaces, provide paint and coating products certified to meet indoor air quality requirements by UL 2818 (Greenguard) Gold, SCS Global Services Indoor Advantage Gold or provide certification by other third-party programs. Provide current product certification documentation from certification body.

G. Manufacturer's Instructions

1. Application Instructions: Indicate special surface preparation procedures.

2. Mixing: Detailed mixing instructions, minimum and maximum application temperature and humidity, potlife, and curing and drying times between coats.

3. Manufacturer's Safety Data Sheets.

H. Maintenance Data: Submit data on cleaning, touch-up, and repair of painted and coated surfaces.

I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. See Section 01 78 43 - Spare Parts and Special Tools, for additional provisions.

2. Extra Paint and Coatings: 1 gallon (4 L) of each color; store where directed.

3. Label each container with color in addition to the manufacturer's label.

1.4 Quality Assurance

A. Required Standards: Coatings subcontractor shall have and maintain on-site during all coating operations the proper industrial standards for use by the Owner or Owner’s representative. Industrial standards to be maintained on-site include:

1. SSPC (Structural Steel Painting Council) Steel Structures Painting Manual, Volume 1.

2. SSPC-VIS-1 - Pictorial Surface Preparation Standards for Painting Steel Surfaces.

B. Required Inspection Tools: Coatings subcontractor shall have and maintain on-site during all coating operations the proper industrial paint inspection tools for use by the Owner or Owner’s representative. Inspection tools to be maintained on-site shall include, as appropriate:

1. Sling psychrometer kit

2. Testex tape kit

3. Zahn Cups Nos. 2, 3, 4 and 5 with a thermometer for air spray paint

4. Nordsen Mikrotest or equal wet mil gauge

5. National Bureau of Standard Calibration Chips

6. Took Gauge

7. Elcometer 10612 Pull Off Adhesion gauge with aluminum dollies and epoxy glue

C. Contractor shall obtain, from the supplier/manufacturer, material safety data sheets (MSDS) for all products, as well as any other special handling, application and cleanup precautions or recommendations. Contractor shall be responsible to follow these safety recommendations and precautions.

D. Single Source Responsibility: Provide primers and other undercoat paint produced by the same manufacturer as finish coats. Use only thinner approved by paint manufacturer and use only within recommended limits.

1.5 Qualifications

A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum five years’ experience in utility applications. The paints and paint products mentioned in the following specifications are set up as standards of quality. No request for substitution will be considered which decreases the film thickness and/or the number of coats to be applied, or which offers a change from the generic type of coating specified.

B. Applicator's Qualifications:

1. Submit the name, address, telephone number, and e-mail address of the contractor that will be performing all surface preparation and coating application. Submit evidence that key personnel have successfully performed surface preparation and application of coatings on a minimum of five similar projects within the past five years. List information by individual and include the following:

a. Name of individual and proposed position for this work.

b. Information about each previous assignment including:

1) Position or responsibility.

2) Employer (if other than the Contractor).

3) Name of facility owner.

4) Mailing address, telephone number, and telex number (if non-US) of facility owner.

5) Name of individual in facility owner's organization who can be contacted as a reference.

6) Location, size and description of structure.

7) Dates work was carried out.

8) Description of work carried out on structure.

1.6 Regulatory Requirements

A. Environmental Protection

1. In addition to requirements specified elsewhere for environmental protection, provide coating materials that conform to the restrictions of the local or regional jurisdiction. Notify Engineer of any paint specified herein which fails to conform.

B. Lead Content: Do not use coatings having a lead content over 0.06 percent by weight of non-volatile content.

C. Chromate Content: Do not use coatings containing zinc-chromate or strontium-chromate.

D. Asbestos Content: Provide asbestos-free materials.

E. Mercury Content: Provide materials free of mercury or mercury compounds.

F. Silica: Provide abrasive blast media containing no free crystalline silica.

G. Human Carcinogens: Provide materials that do not contain ACGIH 0100 confirmed human carcinogens (A1) or suspected human carcinogens (A2).

1.7 Delivery, Storage, and Handling

A. Deliver products to site in sealed and labeled containers; inspect to verify acceptability.

B. Container Label: Include manufacturer's name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.

C. Paint Materials: Store at minimum ambient temperature of 45 degrees F (7 degrees C) and a maximum of 90 degrees F (32 degrees C), in ventilated area, and as required by manufacturer's instructions.

D. Furnish pigmented paints in containers not larger than five gallons.

E. Do not store paint, polyurethane, varnish, or wood stain products with materials that have a high capacity to adsorb VOC emissions. Do not store paint, polyurethane, varnish, or wood stain products in occupied spaces.

1.8 Field Conditions

A. Coatings shall be applied during good painting weather. Air and surface temperatures shall be within limits prescribed by the manufacturer for the coating being applied and work areas shall be reasonably free of airborne dust at the time of application and while coating is drying.

B. Follow manufacturer's recommended procedures for producing best results, including testing of substrates, moisture in substrates, and humidity and temperature limitations.

C. Provide lighting level of 80 ft candles (860 lx) measured mid-height at substrate surface.

1.9 Coordination

A. Coordinate work under provisions of Division 1.

B. Coordination of Work: review other sections of these specifications in which prime paints are to be provided to ensure compatibility of total coatings system for various substrates. Upon request from other trades, furnish information or characteristics of finish materials provided for use, to ensure compatible prime coats are used.

Part 2 Products

2.1 Materials

A. All materials specified herein shall be as manufactured by:

1. TNEMEC Co., Inc., North Kansas City, Missouri.

2. Carboline, St. Louis, Missouri.

3. Induron, Birmingham, Alabama.

4. The Sherwin-Williams Company, Cleveland, Ohio.

5. These products are specified to establish standards of quality and are approved for use on this project.

B. Colors, where not specified, shall be as selected by the A/E from the paint manufacturer’s color chart. All colors shall be certified lead free.

1. In finished areas, finish pipes, ducts, conduit, and equipment the same color as the wall/ceiling they are mounted on/under.

2. In utility areas, finish equipment, piping, conduit, and exposed duct work in colors according to the color coding scheme indicated.

2.2 Paints and Coatings - General

A. Paints and Coatings: Ready mixed, unless intended to be a field-catalyzed coating.

1. Provide paints and coatings of a soft paste consistency, capable of being readily and uniformly dispersed to a homogeneous coating, with good flow and brushing properties, and capable of drying or curing free of streaks or sags.

2. Provide materials that are compatible with one another and the substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.

3. For opaque finishes, tint each coat including primer coat and intermediate coats, one-half shade lighter than succeeding coat, with final finish coat as base color.

4. Supply each coating material in quantity required to complete entire project's work from a single production run.

5. Do not reduce, thin, or dilute coatings or add materials to coatings unless such procedure is specifically described in manufacturer's product instructions.

B. Primers: Where the manufacturer offers options on primers for a particular substrate, use primer categorized as "best" by the manufacturer.

C. Volatile Organic Compound (VOC) Content: Provide coatings that comply with the most stringent requirements specified in the following:

1. Local or state regulations

2. 40 CFR 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings.

3. Determination of VOC Content: Testing and calculation in accordance with 40 CFR 59, Subpart D (EPA Method 24), exclusive of colorants added to a tint base and water added at project site; or other method acceptable to authorities having jurisdiction.

Part 3 Execution

3.1 Examination

A. Verify that surfaces are ready to receive work as instructed by the product manufacturer.

B. Examine surfaces scheduled to be finished prior to commencement of work. Report any condition that may potentially affect proper application.

C. Test shop-applied primer for compatibility with subsequent cover materials.

D. Measure moisture content of surfaces using an electronic moisture meter. Do not apply finishes unless moisture content of surfaces are below the following maximums:

1. Masonry, Concrete, and Concrete Unit Masonry: 12 percent.

2. Concrete Floors and Traffic Surfaces: 8 percent.

3.2 Protection of Areas and Spaces Not to be Painted

A. Prior to surface preparation and coating applications, remove, mask, or otherwise protect hardware, hardware accessories, machined surfaces, radiator covers, plates, lighting fixtures, public and private property, and other such items not to be coated that are in contact with surfaces to be coated.

B. Following completion of painting, reinstall removed items by workmen skilled in the trades.

C. Restore surfaces contaminated by coating materials, to original condition and repair damaged items.

3.3 Surface Preparation

A. Clean surfaces thoroughly and correct defects prior to coating application.

1. Remove dirt, splinters, loose particles, grease, oil, isintegrated coatings, and other foreign matter and substances deleterious to coating performance as specified for each substrate before application of paint or surface treatments.

2. Remove oil and grease prior to mechanical cleaning.

B. Schedule cleaning so that dust and other contaminants will not fall on wet, newly painted surfaces. Spot-prime exposed ferrous metals such as nail heads on or in contact with surfaces to be painted with water-thinned paints, with a suitable corrosion-inhibitive primer capable of preventing flash rusting and compatible with the coating specified for the adjacent areas.

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

D. Additional Requirements for Preparation of Surfaces With Existing Coatings

1. Before application of coatings, perform the following on surfaces covered by soundly-adhered coatings, defined as those which cannot be removed with a putty knife:

a. Test existing finishes for lead before sanding, scraping, or removing. If lead is present, refer to paragraph Toxic Materials.

b. Wipe previously painted surfaces to receive solvent-based coatings, except stucco and similarly rough surfaces clean with a clean, dry cloth saturated with mineral spirits, ASTM D235. Allow surface to dry.

1) Wipe immediately preceding the application of the first coat of any coating, unless specified otherwise.

c. Sand existing glossy surfaces to be painted to reduce gloss. Brush, and wipe clean with a damp cloth to remove dust.

d. The requirements specified are minimum. Comply also with the application instructions of the paint manufacturer.

e. Thoroughly clean previously painted surfaces specified to be repainted or damaged during construction of all grease, dirt, dust or other foreign matter.

f. Remove blistering, cracking, flaking and peeling or otherwise deteriorated coatings.

g. Remove chalk so that when tested in accordance with ASTM D4214, the chalk resistance rating is no less than 8.

h. Roughen slick surfaces. Repair damaged areas such as, but not limited to, nail holes, cracks, chips, and spalls with suitable material to match adjacent undamaged areas.

i. Feather and sand smooth edges of chipped paint.

j. Clean rusty metal surfaces as per SSPC requirements. Use solvent, mechanical, or chemical cleaning methods to provide surfaces suitable for painting.

k. Provide new, proposed coatings that are compatible with existing coatings.

E. Existing Coated Surfaces with Minor Defects

1. Sand, spackle, and treat minor defects to render them smooth. Minor defects are defined as scratches, nicks, cracks, gouges, spalls, alligatoring, chalking, and irregularities due to partial peeling of previous coatings. Remove chalking by sanding or blasting so that when tested in accordance with ASTM D4214, the chalk rating is not less than 8.

F. Removal of Existing Coatings

1. Remove existing coatings from the following surfaces:

a. Surfaces containing large areas of minor defects;

b. Surfaces containing more than 20 percent peeling area; and

c. Surfaces designated by the Engineer, such as surfaces where rust shows through existing coatings.

G. Substrate Repair

1. Repair substrate surface damaged during coating removal;

2. Sand edges of adjacent soundly-adhered existing coatings so they are tapered as smooth as practical to areas involved with coating removal; and

3. Clean and prime the substrate as specified.

3.4 Preparation Of Metal Surfaces

A. Existing and New Ferrous Surfaces

1. Ferrous Surfaces including Shop-coated Surfaces and Small Areas That Contain Rust, Mill Scale and Other Foreign Substances: Solvent clean or detergent wash in accordance with SSPC SP 1 to remove oil and grease. Where shop coat is missing or damaged, clean according to requirements of

painting schedule. Protect shop-coated ferrous surfaces from corrosion by treating and touching up corroded areas immediately upon detection.

2. Surfaces With More Than 20 Percent Rust, Mill Scale, and Other Foreign Substances: Clean entire surface in accordance with painting schedule.

3. Ductile Iron Pipe with Existing Coatings: Existing ductile iron pipes to be recoated shall have existing coating removed by abrasive blast cleaning in accordance with NAPF 500-03-04 for pipe and NAPF 500-03-05 for fittings.

4. Final Ferrous Surface Condition:

   a. For tool cleaned surfaces, the requirements are stated in SSPC SP 2 and SSPC SP 3. Use as a visual reference, photographs in SSPC VIS 3 for the appearance of cleaned surfaces.

   b. For abrasive blast cleaned surfaces, the requirements are stated in SSPC 7/NACE No.4, SSPC SP 6/NACE No.3, and SSPC SP 10/NACE No. 2. Use as a visual reference, photographs in SSPC VIS 1 for the appearance of cleaned surfaces.

   c. For waterjet cleaned surfaces, the requirements are stated in SSPC SP 12/NACE No.5. Use as a visual reference, photographs in SSPC VIS 4/NACE VIS 7 for the appearance of cleaned surfaces.

B. Galvanized Surfaces

1. New or Existing Galvanized Surfaces With Only Dirt and Zinc Oxidation Products: Clean with solvent, steam, or non-alkaline detergent solution in accordance with SSPC SP 1. Completely remove coating by brush-off abrasive blast if the galvanized metal has been passivated or stabilized. Do not "passivate" or "stabilize" new galvanized steel to be coated. If the absence of hexavalent stain inhibitors is not documented, test as described in ASTM D6386, Appendix X2, and remove by one of the methods described therein.

C. Non-Ferrous Metallic Surfaces

1. Aluminum and aluminum-alloy, lead, copper, and other non-ferrous metal surfaces.

   a. Surface Cleaning: Solvent clean in accordance with SSPC SP 1 and wash with mild non-alkaline detergent to remove dirt and water soluble contaminants.

2. Terne-Coated Metal Surfaces

   a. Solvent clean surfaces with mineral spirits, ASTM D235. Wipe dry with clean, dry cloths.

3.5 Preparation of Concrete and Cementitious Surface

A. Concrete and Masonry

1. Curing: Allow concrete, stucco and masonry surfaces to cure at least 30 days before painting, and concrete slab on grade to cure at least 90 days before painting.

2. Surface Cleaning: Remove the following deleterious substances.

   a. Dirt, Chalking, Grease, and Oil: Wash new and existing uncoated surfaces with a solution composed of 1/2 cup trisodium phosphate, 1/4 cup household detergent, and 4 quarts of warm water. Then rinse thoroughly with fresh water. Wash existing coated surfaces with a suitable detergent and rinse thoroughly. For large areas, water blasting may be used.

   b. Fungus and Mold: Wash new, existing coated,and existing uncoated surfaces with a solution composed of 1/2 cup trisodium phosphate, 1/4 cup household detergent, 1 quart 5 percent sodium hypochlorite solution and 3 quarts of warm water. Rinse thoroughly with fresh water.

   c. Paint and Loose Particles: Remove by wire brushing.

   d. Efflorescence: Remove by scraping or wire brushing followed by washing with a 5 to 10 percent by weight aqueous solution of hydrochloric (muriatic) acid. Do not allow acid to remain on the surface for more than five minutes before rinsing with fresh water. Do not acid clean more than 4 square feet of surface, per workman, at one time.

3. Cosmetic Repair of Minor Defects: Repair or fill mortar joints and minor defects, including but not limited to spalls, in accordance with manufacturer's recommendations and prior to coating application.

3.6 Materials Preparation

A. Mix and prepare painting materials in accordance with manufacturer’s directions.

B. Maintain containers used in mixing and application of paint in a clean condition free of foreign materials and residue.

C. Stir materials before application to produce a mixture of uniform density, and stir as required during application. Do not stir surface film into material. Remove film and, if necessary, strain material before using.

D. Two-Component Systems: Mix two-component systems in accordance with manufacturer's instructions. Follow recommendation by the manufacturer for any thinning of the first coat to ensure proper penetration and sealing for each type of substrate.

3.7 Application

A. General: Apply paint in accordance with manufacturer's directions and with SSPC PA 1. SSPC PA 1 methods are applicable to all substrates, except as modified herein.. Use applicators and techniques best suited for substrate and type of material being applied.

1. Provide finish coats which are compatible with prime paints used.

2. Apply additional coats when undercoats, stains or other conditions show through final coat of paint, until a paint film is of uniform finish.

3. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Paint surfaces behind permanently fixed equipment or furniture with prime coat only before final installation of equipment.

4. Sand lightly between each succeeding coat.

5. No paint shall be applied when the air or surface temperature, as measured in the shade, is above or below that which is recommended by the manufacturer.

6. Paint shall not be applied to wet or damp surfaces, and shall not be applied in rain, snow, fog, mist or when the surface temperature will be less than 5°F above the dew point.

7. No paint shall be applied when the air or surface temperature will drop below the manufacturer's recommendation within eight hours after the application of the paint. Dew or moisture condensations should be anticipated, and if such conditions are prevalent, painting shall be delayed until it is certain that the surfaces are dry; further, the day's painting shall be completed well in advance of the probable time of day when the moisture condensation will occur, in order to permit the film the required drying time as specified by the manufacturer prior to the formation of moisture.

8. Care must be exercised that the coatings are not applied in too heavy a coat above that recommended by the manufacturer and that adequate drying time is permitted between the coats to assure the proper release of solvents.

9. Mixing, thinning, pot life, application procedure, equipment, coverage, curing, re-coating, storage and number of coats shall be in accordance with coating manufacturer's instructions.

10. Avoid degradation and contamination of blasted surfaces, and avoid between coat contamination. Surfaces contaminated shall be cleaned before applying next coat. Method of cleaning contaminated surface shall be approved by the Owner or Owner's representative.

11. Each application of material shall be worked into corners, crevices, joints, etc., and distributed evenly over flat surfaces. Spraying techniques that result in

uniform wet pattern shall be used and dry spraying should be avoided. Dry spray shall be removed prior to coating being applied.

12. All bolts, welds, sharp edges, and difficult access areas shall receive a primer brush coat or spray coat prior to primer spray application.

B. Scheduling Painting: Apply first coat material to surfaces that have been cleaned, pre-treated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration. Allow sufficient time between successive coating to permit proper drying. Do not re-coat until paint has dried to where it feels firm, does not deform or feel sticky under moderate thumb pressure, and application of another coat of paint does not cause lifting or loss of adhesion of the undercoat.

C. Minimum Coating Thickness: Apply materials at not less than manufacturer’s recommended spreading rate, to establish a total dry film thickness as recommended by the coating manufacturer.

D. Prime Coats: Apply prime coat of material which is required to be painted or finished, and which has not been prime coated by others. Re-coat primed and sealed surfaces where there is evidence of suction spots or unsealed areas in first coat, to assure a finish coat with no burn-through or other defects due to insufficient sealing.

E. Pigmented (Opaque) Finishes: Completely cover to provide an opaque, smooth surface of uniform finish, color, appearance and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections will not be acceptable.

F. Transparent (Clear) Finishes: Use multiple coats to produce glass-smooth surface film of even luster. Provide a finish free of laps, cloudiness, color irregularity, runs, brush marks, orange peel, nail holes or other surface imperfections.

G. Completed Work: Match approved samples for color, texture and coverage. Remove, refinish, or repaint work not in compliance with specified requirements.

H. Workmanship: Workmanship shall be of first class quality. Finish painting shall show no drips, runs, sags, holidays or other defects. The finish coat shall be free from noticeable laps or brush marks. Paint during application shall be continuously stirred and no thinner shall be added after the paint has been mixed. Paint shall be thoroughly worked into all joints, corners, and well brushed out over all surfaces. Should any coat or paint be judged as unsatisfactory, the Contractor shall remove the coat(s) as necessary and repaint at no additional cost to the Owner.

3.8 Clean-up and Protection

A. Damaged Coatings: Damaged coatings, pinholes, and holidays shall have edges feathered and repaired in accordance with the recommendations of the manufacturer, as approved by the Owner.

B. All finish coats, including touch up and damage repair coats, shall be applied in a manner which will present a uniform texture and color match appearance.

C. Unsatisfactory Application: If the item has an improper finish, color or insufficient film thickness, the surface shall be cleaned and top-coated with the specified material to obtain the specified color and coverage. Specific surface preparation information to be secured from the coatings manufacturer and the Owner.

1. All visible areas of chipped, peeled, or abraded paint shall be hand or power-sanded, feathering the edges. The areas shall then be primed and finish coated in accordance with the specifications.

2. Work shall be free of runs, bridges, shiners, laps or other imperfections. Evidence of these conditions shall be cause for rejection.

3. Any defects in the coating system shall be repaired by the Contractor per written recommendations of the coating manufacturer.

D. Guarantee and Anniversary Inspection

1. All work shall be warranted for a period of one year from date of acceptance of the project.

2. The Owner will notify the Contractor at least 30 days prior to the anniversary date and shall establish a date for the inspection. Any defects in the coating system shall be repaired by the Contractor at no additional cost to the Owner. Should a failure occur to 25% or more of the painted surface, either interior or exterior, the entire surface shall be cleaned and painted in accordance with these specifications.

E. Clean Up

1. All cloths and waste that might constitute a fire hazard shall be placed in closed metal containers or destroyed at the end of each day. Upon completion of the work, all staging, scaffolding, and containers shall be removed from the site and/or destroyed in an approved and legal manner. Paint spots, oil or stains upon adjacent surfaces and floors shall be completely removed, and the entire job left clean and acceptable to the Owner.

3.9 Painting Schedule

A. General:

1. Surfaces not to be Painted:

a. Face brick.

b. Pre-finished ceiling coverings.

c. Pre-finished floor coverings.

d. Items with factory applied final finish.

e. Concealed ducts, pipes, and conduit.

f. Aluminum, except at wall expansion joints.

g. Pre-finished equipment items.

h. Gaskets and expansion joints in piping system.

2. Shop primer on materials and products is not considered as primer coat under the painting schedule.

B. Painting Schedule

Exposures	Surfaces	System Schedules				
		Concrete & Concrete Block Substrate	Non-Ferrous Metals Substrate	Ferrous Metals Substrate	Wood Substrate	Other Substrate
Interior						
	Building Surfaces**	134	-	144	121	
	Equipment*	-	114	144	-	Galvanized Steel: 154
	Piping*	-	114	144	-	Galvanized Steel: 154 PVC: 174
Exterior Above Grade	Building Surfaces**	234	217	247	221	-
	Equipment*	-	217	247	-	-
	Piping*	-	-	247	-	PVC: 277
Exterior Below Grade	Building Surfaces	336	--	346	-	-
	Piping*	-	--	342	-	-
Submerged Wastewater	Immersed Surfaces	532	-	544	-	-
	Piping*	-	-	544	-	--
	Equipment*	-	-	544	-	-
Corrosive Areas	Immersed Surfaces	634	-	644	-	-

Exposures	Surfaces	System Schedules				
		Concrete & Concrete Block Substrate	Non-Ferrous Metals Substrate	Ferrous Metals Substrate	Wood Substrate	Other Substrate
	Equipment	-	-	644	-	-
	Piping	-	-	644	-	-

* See coating, lining, and/or painting paragraphs in individual piping or equipment Specification Sections.

** See finish schedule for where each type shall be used.

C. Schedule Numbering Guide

First Number - Exposure		Second Number - Substrate		Third Number - Coating Type		Final Letter	
1	Interior and Weather Protected	1	Non-Ferrous Metals	1	Alkyd	S	Sewage
2	Exterior Weather Exposure	2	Wood	2	Asphaltic	W	Potable Water
3	Submerged in Potable Water	3	Concrete, Concrete Block, Masonry	4	Epoxy	F	Floors
4	-	4	Ferrous Metals	5	Vinyl	C	Severe Chemical Exposure
5	Submerged in Wastewater	5	Galvanized Ferrous Metals	6	Coal Tar	H	Headspace with High H2S
6	Corrosive Areas	6	Drywall	7	Polyurethane		
		7	PVC Pipe	8	Acrylic		
		8	Fiberglass Reinforced Plastic	9	Zinc		
		9	Other	0	Latex		

D. Material Schedules

System: 247 Surface Preparation: SSPC SP-10
Type: Zinc-Epoxy-Polyurethane
Use: Exterior Ferrous Metal

Coat	Minimum Dry Film Thickness (Mils)	**Carboline**	**Tnemec**	**Induron**	**Sherwin Williams**
1st	3.0-3.5	Carbozinc 859	Series 90-97 Tneme-Zinc	Indurazinc MC67	Zinc-Clad IV or Zinc-Clad III
2nd	6.0-7.0	Carboguard 890	Series N69-Color Epoxoline II	Perma-Clean II Epoxy	Macropoxy 646 Epoxy
3rd	2.5-3.0	Carbothane 133 HB	Series 1074-Color EnduraShield II	Indurathane 6600 Plus	Acrolon 7300
System	11.5-16.5				

System: 257 Surface Preparation: In accordance with manufacturer's recommendations
Type: Epoxy Polyurethane
Use: Galvanized Steel

Coat	Minimum Dry Film Thickness (Mils)	**Carboline**	**Tnemec**	**Induron**	**Sherwin Williams**
1st	2.5-3.0	Carboguard 635	Series 27 Typoxy	Induramastic 85	Macropoxy 646 FC Epoxy
2nd	4.0-5.0	Carboguard 890	Series N69-Color Hi-Build Epoxoline II	Perma-Clean II Epoxy	Macropoxy 646 FC Epoxy
3rd	2.5-3.0	Carbothane 133	Series 1074-Color Endura-Shield II	Indurathane 6600 Plus	Acrolon 7300
System	9.0-11.0				

System: 342 Surface Preparation: SP-2 or SP-3
Type: Asphaltic
Use: Below Grade Piping

Coat	Minimum Dry Film Thickness (Mils)	**Carboline**	**Tnemec**	**Induron**	**Sherwin Williams**
1st	8.0 – 12.0	Bitumastic 300 M	46-465 H.B. Tnemecol	Ceramawrap	Targuard
2nd	As Needed				
System	10.0				

System: 346 Type: Epoxy-Coal Tar Use: Exterior Below Grade Ferrous Metal			Surface Preparation: SSPC SP-10		
Coat	Minimum Dry Film Thickness (Mils)	**Carboline**	**Tnemec**	**Induron**	**Sherwin Williams**
1st	6.0-7.0	Carboguard 890	Series N69-Color Epoxoline II	Ruff-Stuff 2100	Hi-Mil Sher-Tar Epoxy
2nd	14-16	Bitumastic 300M	Series 46H-413 Hi-Build Tneme-Tar	Ruff-Stuff 2100	Hi-Mil Sher-Tar Epoxy
System	20				

System: 532 Type: Asphaltic Use: Immersed Concrete Surfaces		Surface Preparation: Abrasive Sweep Blast per SSPC-SP13 / NACE No.6			
Coat	Minimum Dry Film Thickness (Mils)	**Carboline**	**Tnemec**	**Induron**	**Sherwin Williams**
1st	16.0 - 20.0	Bitumastic 300M	Series 46H-413 Hi Build Tneme-Tar	Ruff-Stuff 2100	Targuard
System	16.0				

System: 644 Type: Cycloaliphatic Epoxy Use: Corrosive Environment Ferrous Metal			Surface Preparation: SSPC SP-10			
Coat	Minimum Dry Film Thickness (Mils)	**Carboline**	**Tnemec**	**Induron**	**Sherwin Williams**	
1st	3.0 – 5.0	Carbozinc 859	Series 90-97 Tneme-Zinc	Ceramaprime	Zinc Clad IV or III	
2nd	6.0	Carboguard 890	Series N69-Color Hi-Build Epoxoline II	Ceramasafe 90 @ 15-20 mils	Dura Plate 235 B67-235	
3rd	6.0	Carboguard 890	Series N69-Color Hi-Build Epoxoline II	Ceramasafe 90 @ 15-20 mils	Dura Plate 235 B67-235	
System	15.0-17.0					

END OF SECTION

Part 1 General

1.1 Summary

A. Contractor to furnish a precast concrete building. Building panels and roof sections to be delivered and placed on prepared foundation in accordance with manufacturer's recommendations. Building to be provided by manufacturer with all necessary openings as specified by contractor in conformance with manufacturer's structural requirements.

B. Building to be delivered and placed on owner's foundation. Foundation sized as shown on plans.

1.2 Manufacturers

A. The supplier shall furnish, install, interconnect, and test the equipment and materials specified herein, as well as any equipment specified in any related documents. The requirements included in this specification shall also apply and be applicable to the integrated power assembly (IPA) specification 26 05 91 regarding prefabricated E-Houses.

1.3 Quality Assurance

A. ACI-318-11, "Building Code Requirements for Reinforced Concrete".

B. ANSI/ASCE-7-10 "Building Code Requirement for Minimum Design Loads in Buildings and Other Structures".

C. 2017 Georgia Building Code

D. 2012 IECC or ANSI/ASHRAE/IES 90.1-2010

E. Concrete Reinforcing Institute, "Manual of Standard Practice".

F. Fabricator must be a producer/member of Precast/Prestressed Concrete Institute (PCI) and be certified in categories A1, B1, and C3.

G. Building fabricator must have a minimum of 5 years’ experience manufacturing and setting transportable precast concrete buildings.

1.4 Design Requirements

A. Dimensions:

1. The building dimensions shall be according to the electrical plans.

B. Design Loads:

1. As indicated on drawings.

C. Roof: Roof panel shall have a peak in center of 16-foot direction (or as indicated on drawings) and shall have a 3:12 gable pitch unless otherwise indicated on plans. The roof shall extend a minimum of 3" beyond the wall panel on each side and have a turndown design which extends 1" below the top edge of the wall panels to prevent water migration into the building along top of wall panels. Roof shall be 5" thick, broom finish stained one color.

D. Roof and wall panels must each be produced as single component monolithic panels. No roof or vertical wall joints will be allowed, except at corners. Wall panels shall be set on top of floor panel.

1.5 Submittals

A. Engineering calculations that are designed and sealed by a professional engineer, licensed to practice in the state where the project is located, shall be submitted for approval.

2.1 Materials

A. Concrete: Steel-reinforced, 5000 PSI minimum 28-day compressive strength, air-entrained (ASTM C260).

B. Reinforcing Steel: ASTM A615, grade 60 unless otherwise specified.

C. Post-Tensioning Strand: 41K Polystrand CP50, .50, 270 KSI, 7-wire strand, enclosed within a greased plastic sheath, (ASTM A416), roof and floor to be each post-tensioned by a single, continuous tendon. Said tendon shall form a substantially rectangular configuration having gently curving corners wherein the positioning of the cable member results in a pattern of one or more loops and a bisecting of the loop(s). The cable member starts from one corner of the concrete building panel, forms a gentle perimeter loop(s) returning to a point where the cable member entered the concrete building panel. The tendon then turns 90 degrees and follows the cable member(s) to a point midway along the "Y" axis of the concrete building panel and then turns 90 degrees along the "X" axis of the concrete building panel. This bisects the concrete building panel and crosses the opposite parallel portion of the cable member and exits from an adjacent side of the concrete building panel.

1. If post-tensioning is not used in the roof panel, the following guidelines must be followed to ensure a watertight roof design.

a. The entire precast concrete roof panel surface must be cleaned and primed with a material that prepares the concrete surface for proper adherence to the coating material.

b. The entire precast concrete roof panel surface shall be sealed with a .045 EPDM continuous membrane cemented to the concrete with a compound designed for this purpose.

D. Caulking: All joints between panels shall be caulked on the exterior and interior surface of the joints. Caulking shall be SIKAFLEX-1A elastic sealant or equal. Exterior caulk joint to be 3/8" x 3/8" square so that sides of joint are parallel for correct caulk adhesion. Back of joint to be taped with bond breaking tape to ensure adhesion of caulk to parallel sides of joint and not the back.

E. Panel Connections: All panels shall be securely fastened together with 3/8" thick steel brackets. Steel is to be of structural quality, hot-rolled carbon complying with ASTM A283, Grade C and hot dipped galvanized after fabrication. All fasteners to be (" diameter bolts complying with ASTM A307 for low-carbon steel bolts. Cast-in anchors used for panel connections to be Dayton-Superior #F-63 or equal. All inserts for corner connections must be bolted directly to form before casting panels. No floating-in of connection inserts shall be allowed.

2.2 Accessories

A. Doors and Frames: Shall comply with Steel Door Institute "Recommended Specifications for Standard Steel Doors and Frames" (SDI-100) and as herein specified. The building shall be equipped with one (1) double 3'-0" x 6'-8" x 1-3/4", 18-gauge galvanized/insulated Dominion Imperial right hand reverse metal door with 16-gauge galvanized frames. Door and frame shall be bonderized and painted one coat of rust inhibitive primer and one finish coat of enamel paint; color shall be Yorktown Brown unless otherwise specified.

B. Door Hardware:

1. Handle: Lindstrom stainless steel, 8" x 2" or equal.

2. Hinges: PB-31/NRP/26D 4" x 4" chrome-plated with non-removable hinge pins, 3 per door or equal.

3. Lock Set: PDQ Industries KR116 - 32D, stainless steel finish or equal.

4. Surface Bolt, Upper: Cal-Royal 045901726D, satin chrome finish or equal.

5. Surface Bolt, Lower: Cal-Royal 045901426D, satin chrome finish or equal.

6. Astragal: A4441/68R or equal.

7. Threshold: National Guard 897V60 raised interior, extruded aluminum threshold with neoprene seal or equal.

8. Door Holder: Glynn-Johnson 904H US32D, stainless steel finish, overhead slide type surface mounted door holder or equal.

9. Drip Cap: National Guard 15D72 or equal.

10. Door Stop: Ives 445B26D (Inactive leaf only) or equal.

2.3 Finishes

A. Interior of Building: Smooth concrete finish, non stained.

B. Exterior of Building: Architectural precast concrete brick finish (unless otherwise specified) -- Finish must be imprinted in top face of panel while in form using an open grid impression tool. Finished brick size shall be 2 3/8" x 7 5/8" with vertical steel float or light broom finish. Joints between each brick must be 3/8" wide and 3/8" deep. Back off joint shall be concave to simulate a hand-tooled joint. Each brick face shall be coated with the following acrylic concrete stain: 1) Cement rate by FOSROC or 2) Canyon Tone stain by United Coatings. Stain color shall be Brick Red unless specified otherwise. Stain shall be applied per manufacturer's recommendation. Joints shall be kept substantially free of stain to maintain a gray concrete color.
Not suitable for application over existing water repellents.
Not suitable for horizontal surfaces.
May blush on certain substrates.

C. Precast Concrete Roof - broom finish, roof to be stained one color, color to be selected by owner.

3.1 Electrical Package:

A. Basic electrical package for building:

1. Shall be in accordance with electrical plans and according to specification 26 05 91, integrated power assembly (IPA).

B. Insulation Package:

1. All interior walls and ceilings to be covered with rigid insulation meeting the requirements of the 2012 IECC. Rigid insulation to be covered with 1/2" of plywood with white FRP paneling.

END OF SECTION

Part 1 GENERAL

1.1 Summary

A. Section Includes:

1. Structural-steel framing.
2. Metal roof panels.
3. Metal wall panels.
4. Metal soffit panels.
5. Thermal insulation.
6. Personnel doors and frames.
7. Windows.
8. Accessories.

1.2 Preinstallation Meetings

A. Preinstallation Conference: Conduct conference at Project site.

1.3 Action Submittals

A. Product Data: For each type of metal building system component.

B. Shop Drawings: Indicate components by others. Include full building plan, elevations, sections, details and attachments to other work.

C. Delegated Design Submittals: For metal building systems.

1. Include analysis data indicating compliance with performance requirements and design data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 Informational Submittals

A. Welding certificates.

B. Letter of Design Certification: Signed and sealed by a qualified professional engineer. Include the following:

1. Name and location of Project.

2. Order number.

3. Name of manufacturer.

4. Name of Contractor.

5. Building dimensions including width, length, height, and roof slope.

6. Indicate compliance with AISC standards for hot-rolled steel and AISI standards for cold-rolled steel, including edition dates of each standard.

7. Governing building code and year of edition.

8. Design Loads: Include dead load, roof live load, collateral loads, roof snow load, deflection, wind loads/speeds and exposure, seismic design category or effective peak velocity-related acceleration/peak acceleration, and auxiliary loads (cranes).

9. Load Combinations: Indicate that loads were applied acting simultaneously with concentrated loads, according to governing building code.

10. Building-Use Category: Indicate category of building use and its effect on load importance factors.

C. Material test reports.

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample warranties.

1.5 Closeout Submittals

A. Maintenance data.

1.6 Quality Assurance

A. Manufacturer Qualifications: A qualified manufacturer.

1. Accreditation: Manufacturer's facility accredited according to IAS AC472, "Accreditation Criteria for Inspection Programs for Manufacturers of Metal Building Systems."

2. Engineering Responsibility: Preparation of comprehensive engineering analysis and Shop Drawings by a professional engineer who is legally qualified to practice in jurisdiction where Project is located.

B. Erector Qualifications: An experienced erector who specializes in erecting and installing work similar in material, design, and extent to that indicated for this Project and who is acceptable to manufacturer.

C. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.3, "Structural Welding Code - Sheet Steel."

1.7 Warranty

A. Special Warranty on Metal Panel Finishes: Manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Finish Warranty Period: 20 years from date of Substantial Completion.

B. Special Weathertightness Warranty for Standing-Seam Metal Roof Panels: Manufacturer agrees to repair or replace standing-seam metal roof panel assemblies that leak or otherwise fail to remain weathertight within specified warranty period.

1. Warranty Period: 20 years from date of Substantial Completion.

Part 2 PRODUCTS

2.1 Manufacturers

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

1. ACI Building Systems, Inc.
2. All American Systems; a division of NCI Building Systems, Inc.
3. American Buildings Company; a Nucor company.
4. Butler Manufacturing Company; a division of BlueScope Buildings North America, Inc.
5. Ceco Building Systems; part of the Cornerstone Building Brands.
6. Varco-Pruden Buildings; a division of BlueScope Buildings North America, Inc.

2.2 Performance Requirements

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00 "Quality Requirements," to design metal building system.

B. Structural Performance: Metal building systems to withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to procedures in MBMA's "Metal Building Systems Manual."

1. Design Loads: As indicated on Drawings.

2. Deflection and Drift Limits:

a. Design metal building system assemblies to withstand serviceability design loads without exceeding deflections and drift limits recommended in AISC Steel Design Guide No. 3 "Serviceability Design Considerations for Steel Buildings."

b. No greater than the following:

1) Purlins and Rafters: Vertical deflection of 1/240 of the span.

2) Girts: Horizontal deflection of 1/180 of the span.

3) Metal Roof Panels: Vertical deflection of 1/240 of the span.

4) Metal Wall Panels: Horizontal deflection of 1/240 of the span.

5) Design secondary-framing system to accommodate deflection of primary framing and construction tolerances, and to maintain clearances at openings.

6) Lateral Drift: Maximum of 1/200 of the building height.

C. Seismic Performance: Metal building system to withstand the effects of earthquake motions determined according to ASCE/SEI 7.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

E. Fire-Resistance Ratings: Where assemblies are indicated to have a fire-resistance rating, provide metal panel assemblies identical to those of assemblies tested for fire resistance per ASTM E119 or ASTM E108 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Indicate design designations from UL's "Fire Resistance Directory," FM Global's "Approval Guide," or from the listings of another qualified testing agency.

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

   1. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.

G. Structural Performance for Metal Roof Panels: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E1592:

   1. Wind Loads: As indicated on Drawings.

H. Air Infiltration for Metal Roof Panels: Air leakage of not more than 0.06 cfm/sq. ft. when tested according to ASTM E1680 at the following test-pressure difference:

   1. Test-Pressure Difference: 1.57 lbf/sq. ft.

I. Air Infiltration for Metal Wall Panels: Air leakage of not more than 0.06 cfm/sq. ft. when tested according to ASTM E283 at the following test-pressure difference:

   1. Test-Pressure Difference: 1.57 lbf/sq. ft.

J. Water Penetration for Metal Roof Panels: No water penetration when tested according to ASTM E1646 at the following test-pressure difference:

   1. Test-Pressure Difference: 2.86 lbf/sq. ft.

K. Water Penetration for Metal Wall Panels: No water penetration when tested according to ASTM E331 at the following test-pressure difference:

   1. Test-Pressure Difference: 2.86 lbf/sq. ft.

L. Wind-Uplift Resistance: Provide metal roof panel assemblies that comply with UL 580 for wind-uplift-resistance class indicated.

   1. Uplift Rating: UL 90.

M. FM Global Listing: Provide metal roof panels and component materials that comply with requirements in FM Global 4471 as part of a panel roofing system and that are listed in FM Global's "Approval Guide" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Global markings.

   1. Fire/Windstorm Classification: Class 1A- 90.

   2. Hail Resistance: SH.

2.3 Structural-Steel Framing

A. Structural Steel: Comply with AISC 360, "Specification for Structural Steel Buildings."

B. Bolted Connections: Comply with RCSC's "Specification for Structural Joints Using High-Strength Bolts."

C. Cold-Formed Steel: Comply with AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members" for design requirements and allowable stresses.

D. Primary Framing: Manufacturer's standard primary-framing system, designed to withstand required loads and specified requirements. Primary framing includes transverse and lean-to frames; rafters and rake beams; sidewall, intermediate, end-wall, and corner columns; and wind bracing.

1. General: Provide frames with attachment plates, bearing plates, and splice members. Factory drill for field-bolted assembly. Provide frame span and spacing indicated.

    a. Slight variations in span and spacing may be acceptable if necessary to comply with manufacturer's standard, as approved by Architect.

2. Frame Configurations: Single gable and One-directional, sloped.

3. Exterior Column: Uniform depth.

4. Rafter: Uniform depth.

E. End-Wall Framing: Manufacturer's standard primary end-wall framing fabricated for field-bolted assembly to comply with the following:

F. Secondary Framing: Manufacturer's standard secondary framing, including purlins, girts, eave struts, flange bracing, base members, gable angles, clips, headers, jambs, and other miscellaneous structural members. Unless otherwise indicated, fabricate framing from either cold-formed, structural-steel sheet or roll-formed, metallic-coated steel sheet, prepainted with coil coating, to comply with the following:

G. Anchor Rods: Headed anchor rods as indicated in Anchor Rod Plan for attachment of metal building to foundation.

2.4 Metal Roof Panels

A. Standing-Seam, Vertical-Rib, Metal Roof Panels: Formed with interlocking ribs at panel edges and intermediate stiffening ribs symmetrically spaced between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels and engaging opposite edge of adjacent panels.

1. Material: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.024-inch nominal uncoated steel thickness. Prepainted by the coil-coating process to comply with ASTM A755/A755M.

    a. Exterior Finish: Two-coat fluoropolymer.

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

2. Clips: Two-piece floating to accommodate thermal movement.

3. Joint Type: Mechanically seamed.

4. Panel Coverage: 16 inches.

5. Panel Height: 3 inches.

2.5 Metal Soffit Panels

A. General: Provide factory-formed metal soffit panels designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant in side laps. Include accessories required for weathertight installation.

B. Metal Soffit Panels: Match profile and material of metal roof panels.

1. Finish: Match finish and color of metal roof panels.

2.6 Accessories

A. General: Provide accessories as standard with metal building system manufacturer and as specified. Fabricate and finish accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes. Comply with indicated profiles and with dimensional and structural requirements.

1. Form exposed sheet metal accessories that are without excessive oil-canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.

B. Roof Panel Accessories: Provide components required for a complete metal roof panel assembly including copings, fasciae, corner units, ridge closures, clips, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal roof panels unless otherwise indicated.

C. Wall Panel Accessories: Provide components required for a complete metal wall panel assembly including copings, fasciae, mullions, sills, corner units, clips, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal wall panels unless otherwise indicated.

D. Flashing and Trim: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch nominal uncoated steel thickness, prepainted with coil coating; finished to match adjacent metal panels.

E. Gutters: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch nominal uncoated steel thickness, prepainted with coil coating; finished to match roof fascia and rake trim. Match profile of gable trim, complete with end pieces, outlet tubes, and other special pieces as required. Fabricate in minimum 96-inch- long sections, sized according to SMACNA's "Architectural Sheet Metal Manual."

1. Gutter Supports: Fabricated from same material and finish as gutters.

2. Strainers: Bronze, copper, or aluminum wire ball type at outlets.

F. Downspouts: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch nominal uncoated steel thickness, prepainted with coil coating; finished to match metal wall panels. Fabricate in minimum 10-foot- long sections, complete with formed elbows and offsets.

1. Mounting Straps: Fabricated from same material and finish as gutters.

G. Roof Ventilators: Gravity type, complete with hardware, flashing, closures, and fittings.

1. Circular-Revolving Type: Minimum 20-inch- diameter throat opening; zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.024-inch nominal uncoated steel thickness, with coil coating; finished to match metal roof panels; with matching base and rain cap.

   a. Type: Directional revolving.

   b. Bird Screening: Galvanized steel, 1/2-inch- square mesh, 0.041-inch wire; or aluminum, 1/2-inch- square mesh, 0.063-inch wire.

   c. Dampers: Spring-loaded, butterfly type; pull-chain operation; with pull chain of length required to reach within 36 inches of floor.

2. Continuous or Sectional-Ridge Type: Factory-engineered and -fabricated, continuous unit; Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch nominal uncoated steel thickness, prepainted with coil coating; finished to match metal roof panels. Fabricated in minimum 10-foot-long sections. Provide throat size and total length indicated, complete with side baffles, ventilator assembly, end caps, splice plates, and reinforcing diaphragms.

   a. Bird Screening: Galvanized steel, 1/2-inch- square mesh, 0.041-inch wire; or aluminum, 1/2-inch- square mesh, 0.063-inch wire.

b. Dampers: Manually operated, spring-loaded, vertically rising type; chain and worm gear operator; with pull chain of length required to reach within 36 inches of floor.

c. Throat Size: As standard with manufacturer, and as required to comply with ventilation requirements.

H. Roof Curbs: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.048-inch nominal uncoated steel thickness prepainted with coil coating; finished to match metal roof panels; with welded top box and bottom skirt, and integral full-length cricket; capable of withstanding loads of size and height indicated.

I. Pipe Flashing: Premolded, EPDM pipe collar with flexible aluminum ring bonded to base.

2.7 Fabrication

A. General: Design components and field connections required for erection to permit easy assembly.

1. Mark each piece and part of the assembly to correspond with previously prepared erection drawings, diagrams, and instruction manuals.

2. Fabricate structural framing to produce clean, smooth cuts and bends. Punch holes of proper size, shape, and location. Members to be free of cracks, tears, and ruptures.

B. Tolerances: Comply with MBMA's "Metal Building Systems Manual" for fabrication and erection tolerances.

C. Primary Framing: Shop fabricate framing components to indicated size and section, with baseplates, bearing plates, stiffeners, and other items required for erection welded into place. Cut, form, punch, drill, and weld framing for bolted field assembly.

D. Secondary Framing: Shop fabricate framing components to indicated size and section by roll forming or break forming, with baseplates, bearing plates, stiffeners, and other plates required for erection welded into place. Cut, form, punch, drill, and weld secondary framing for bolted field connections to primary framing.

E. Metal Panels: Fabricate and finish metal panels at the factory to greatest extent possible, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements. Comply with indicated profiles and with dimensional and structural requirements.

1. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of metal panel.

2.8 Source Quality Control

A. Special Inspection: Owner will engage a qualified special inspector to perform source quality control inspections and to submit reports.

1. Accredited Manufacturers: Special inspections will not be required if fabrication is performed by an IAS AC472-accredited manufacturer approved by authorities having jurisdiction to perform such Work without special inspection.

B. Product will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

Part 3 EXECUTION

3.1 Erection Of Structural Framing

A. Erect metal building system according to manufacturer's written instructions and drawings.

B. Do not field cut, drill, or alter structural members without written approval from metal building system manufacturer's professional engineer.

C. Set structural framing accurately in locations and to elevations indicated, according to AISC specifications referenced in this Section. Maintain structural stability of frame during erection.

D. Base and Bearing Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.

1. Set plates for structural members on wedges, shims, or setting nuts as required.

2. Tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.

3. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.

E. Align and adjust structural framing before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with framing. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

1. Level and plumb individual members of structure.

2. Make allowances for difference between temperature at time of erection and mean temperature when structure will be completed and in service.

F. Primary Framing and End Walls: Erect framing level, plumb, rigid, secure, and true to line. Level baseplates to a true even plane with full bearing to supporting structures, set with double-nutted anchor bolts. Use grout to obtain uniform bearing and to maintain a level base-line elevation. Moist-cure grout for not less than seven days after placement.

1. Make field connections using high-strength bolts installed according to RCSC's "Specification for Structural Joints Using High-Strength Bolts" for bolt type and joint type specified.

   a. Joint Type: Snug tightened or pretensioned as required by manufacturer.

G. Secondary Framing: Erect framing level, plumb, rigid, secure, and true to line. Field bolt secondary framing to clips attached to primary framing.

1. Provide rake or gable purlins with tight-fitting closure channels and fasciae.

2. Locate and space wall girts to suit openings such as doors and windows.

3. Provide supplemental framing at entire perimeter of openings, including doors, windows, ventilators, and other penetrations of roof and walls.

H. Steel Joists: Install joists and accessories plumb, square, and true to line; securely fasten to supporting construction according to SJI's "Standard Specifications and Load Tables for Steel Joists and Joist Girders," joist manufacturer's written instructions, and requirements in this Section.

1. Before installation, splice joists delivered to Project site in more than one piece.

2. Space, adjust, and align joists accurately in location before permanently fastening.

3. Install temporary bracing and erection bridging, connections, and anchors to ensure that joists are stabilized during construction.

4. Joist Installation:

   a. Bolt joists to supporting steel framework using carbon-steel bolts unless otherwise indicated.

   b. Bolt joists to supporting steel framework using high-strength structural bolts unless otherwise indicated. Comply with RCSC's "Specification for

Structural Joints Using High-Strength Bolts" for high-strength structural bolt installation and tightening requirements.

c. Weld joist seats to supporting steel framework.

5. Install and connect bridging concurrently with joist erection, before construction loads are applied. Anchor ends of bridging lines at top and bottom chords if terminating at walls or beams.

I. Bracing: Install bracing in roof and sidewalls where indicated on erection drawings.

1. Tighten rod and cable bracing to avoid sag.

2. Locate interior end-bay bracing only where indicated.

J. Framing for Openings: Provide shapes of proper design and size to reinforce openings and to carry loads and vibrations imposed, including equipment furnished under mechanical and electrical work. Securely attach to structural framing.

K. Erection Tolerances: Maintain erection tolerances of structural framing within AISC 303.

3.2 Metal Panel Installation, General

A. General: Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Field cut metal panels as required for doors, windows, and other openings. Cut openings as small as possible, neatly to size required, and without damage to adjacent metal panel finishes.

a. Field cutting of metal panels by torch is not permitted unless approved in writing by manufacturer.

2. Install metal panels perpendicular to structural supports unless otherwise indicated.

3. Flash and seal metal panels with weather closures at perimeter of openings and similar elements. Fasten with self-tapping screws.

4. Locate and space fastenings in uniform vertical and horizontal alignment.

5. Locate metal panel splices over structural supports with end laps in alignment.

6. Lap metal flashing over metal panels to allow moisture to run over and off the material.

B. Lap-Seam Metal Panels: Install screw fasteners using power tools with controlled torque adjusted to compress EPDM washers tightly without damage to washers, screw threads, or metal panels. Install screws in predrilled holes.

1. Arrange and nest side-lap joints so prevailing winds blow over, not into, lapped joints. Lap ribbed or fluted sheets one full rib corrugation. Apply metal panels and associated items for neat and weathertight enclosure. Avoid "panel creep" or application not true to line.

C. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with corrosion-resistant coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by metal roof panel manufacturer.

D. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weatherproof performance of metal panel assemblies. Provide types of gaskets, fillers, and sealants indicated; or, if not indicated, provide types recommended by metal panel manufacturer.

1. Seal metal panel end laps with double beads of tape or sealant the full width of panel. Seal side joints where recommended by metal panel manufacturer.

2. Prepare joints and apply sealants to comply with requirements in Section 07 92 00 "Joint Sealants."

3.3 Metal Roof Panel Installation

A. General: Provide metal roof panels of full length from eave to ridge unless otherwise indicated or restricted by shipping limitations.

1. Install ridge and hip caps as metal roof panel work proceeds.

2. Flash and seal metal roof panels with weather closures at eaves and rakes. Fasten with self-tapping screws.

B. Standing-Seam Metal Roof Panels: Fasten metal roof panels to supports with concealed clips at each standing-seam joint, at location and spacing and with fasteners recommended by manufacturer.

1. Install clips to supports with self-drilling or self-tapping fasteners.

2. Install pressure plates at locations indicated in manufacturer's written installation instructions.

3. Snap Joint: Nest standing seams and fasten together by interlocking and completely engaging factory-applied sealant.

4. Seamed Joint: Crimp standing seams with manufacturer-approved motorized seamer tool so that clip, metal roof panel, and factory-applied sealant are completely engaged.

5. Rigidly fasten eave end of metal roof panels and allow ridge end free movement for thermal expansion and contraction. Predrill panels for fasteners.

6. Provide metal closures at peaks, rake edges, rake walls, and each side of ridge and hip caps.

C. Lap-Seam Metal Roof Panels: Fasten metal roof panels to supports with exposed fasteners at each lapped joint, at location and spacing recommended by manufacturer.

1. Provide metal-backed sealing washers under heads of exposed fasteners bearing on weather side of metal roof panels.

2. Provide sealant tape at lapped joints of metal roof panels and between panels and protruding equipment, vents, and accessories.

3. Apply a continuous ribbon of sealant tape to weather-side surface of fastenings on end laps and on side laps of nesting-type metal panels, on side laps of ribbed or fluted metal panels, and elsewhere as needed to make metal panels weatherproof to driving rains.

4. At metal panel splices, nest panels with minimum 6-inch end lap, sealed with butyl-rubber sealant and fastened together by interlocking clamping plates.

D. Metal Fascia Panels: Align bottom of metal panels and fasten with blind rivets, bolts, or self-drilling or self-tapping screws. Flash and seal metal panels with weather closures where fasciae meet soffits, along lower panel edges, and at perimeter of all openings.

3.4 Metal Soffit Panel Installation

A. Provide metal soffit panels the full width of soffits. Install panels perpendicular to support framing.

B. Flash and seal metal soffit panels with weather closures where panels meet walls and at perimeter of all openings.

3.5 Accessory Installation

A. General: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal roof panel assembly, including trim, copings, ridge closures, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.

2. Install components for a complete metal wall panel assembly, including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.

3. Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with corrosion-resistant coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by manufacturer.

B. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.

1. Install exposed flashing and trim that is without excessive oil-canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.

2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with mastic sealant (concealed within joints).

C. Gutters: Join sections with riveted-and-soldered or lapped-and-sealed joints. Attach gutters to eave with gutter hangers spaced as required for gutter size, but not more than 36 inches o.c. using manufacturer's standard fasteners. Provide end closures and seal watertight with sealant. Provide for thermal expansion.

D. Downspouts: Join sections with 1-1/2-inch telescoping joints. Provide fasteners designed to hold downspouts securely 1 inch away from walls; locate fasteners at top and bottom and at approximately 60 inches o.c. in between.

1. Provide elbows at base of downspouts to direct water away from building.

2. Tie downspouts to underground drainage system indicated.

E. Circular Roof Ventilators: Set ventilators complete with necessary hardware, anchors, dampers, weather guards, rain caps, and equipment supports. Mount ventilators on flat level base. Install preformed filler strips at base to seal ventilator to metal roof panels.

F. Continuous Roof Ventilators: Set ventilators complete with necessary hardware, anchors, dampers, weather guards, rain caps, and equipment supports. Join sections with splice plates and end-cap skirt assemblies where required to achieve indicated length. Install preformed filler strips at base to seal ventilator to metal roof panels.

G. Roof Curbs: Install curbs at locations indicated on Drawings. Install flashing around bases where they meet metal roof panels.

H. Pipe Flashing: Form flashing around pipe penetration and metal roof panels. Fasten and seal to panel as recommended by manufacturer.

3.6 Field Quality Control

A. Special Inspections: Owner will engage a qualified special inspector to perform field quality control special inspections and to submit reports.

B. Product will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION

Part 1 General

1.1 Summary

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 Coordination

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

Part 2 Products

2.1 General Motor Requirements

A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 Motor Characteristics

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 Polyphase Motors

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.

2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.

2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 Additional Requirements For Polyphase Motors

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers:

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.

2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.

3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.

4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 Single-Phase Motors

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.

2. Split phase.

3. Capacitor start, inductor run.

4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

Part 3 Execution (NOT APPLICABLE)

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Elastomeric isolation pads.

2. Elastomeric isolation mounts.

3. Restrained elastomeric isolation mounts.

4. Restraints - rigid type.

5. Restraints - cable type.

6. Restraint accessories.

7. Post-installed concrete anchors.

1.2 Action Submittals

A. Product Data: For each type of product.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases.

2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated Design Submittals:

1. For each seismic-restraint and wind-load protection device, including seismic-restrained mounting, pipe-riser resilient support, seismic restraint, seismic-restraint accessory, concrete anchor and insert, that is required by this Section or is indicated on Drawings, submit the following:

a. Seismic and Wind-Load Restraint, and Vibration Isolation Base Selection: Select vibration isolators, seismic and wind-load restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data.

b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification by professional engineer that riser system was examined for excessive stress and that none exists.

c. Concrete Anchors and Inserts: Include calculations showing anticipated seismic and wind loads. Include certification that device is approved by an NRTL for seismic reinforcement use.

d. Seismic Design Calculations: Submit all input data and loading calculations prepared under "Seismic Design Calculations" Paragraph in "Performance Requirements" Article.

e. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared under "Wind-Load Design Calculations" Paragraph in "Performance Requirements" Article.

f. Qualified Professional Engineer: All designated-design submittals for seismic- and wind-restraint calculations are to be signed and sealed by qualified professional engineer responsible for their preparation.

2. Seismic- and Wind-Restraint Detail Drawing:

a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.

b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply also with requirements in other Sections for equipment mounted outdoors.

3. All delegated design submittals for seismic- and wind-restraint detail Drawings are to be signed and sealed by qualified professional engineer responsible for their preparation.

4. Product Listing, Preapproval, and Evaluation Documentation: By UL FM Approvals, showing maximum ratings of restraint items and basis for approval (tests or calculations).

5. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.

6. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on

building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

1.3 Informational Submittals

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Welding certificates.

C. Field quality-control reports.

D. Seismic Qualification Data: Provide special certification for designated seismic systems as indicated in ASCE/SEI 7-16, Paragraph 13.2.2, "Special Certification Requirements for Designated Seismic Systems" for all Designated Seismic Systems identified as such on Drawings or in the Specifications.

1. Provide equipment manufacturer's written certification for each designated active mechanical seismic device and system, stating that it will remain operable following the design earthquake. Certification must be based on requirements of ASCE/SEI 7 and AHRI 1270, including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction or ASCE/SEI 7-16.

2. Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in ASCE/SEI 7-16.

3. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.

E. Wind-Force Performance Certification: Provide special certification for HVAC components subject to high wind exposure and impact damage and designated on Drawings or in the Specifications to require wind-force performance certification.

1. Provide equipment manufacturer's written certification for each designated HVAC device, stating that it will remain in place and operable following the design wind event and comply with all requirements of authorities having jurisdiction.

2. Provide manufacturer's written certification for each designated louver, damper, or similar device, stating that it will remain in place and protect opening from penetration of windborne debris and comply with all requirements of authorities having jurisdiction.

3. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction.

1.4 Quality Assurance

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7, and be acceptable to authorities having jurisdiction.

B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic- and Wind-Load-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: UL product listing FM Approvals.

Part 2 Products

2.1 Performance Requirements

A. Delegated Design: Engage a qualified professional engineer to design seismic and wind- load control system.

1. Seismic and Wind-Load Performance: Equipment to withstand the effects of earthquake motions and high wind events determined in accordance with ASCE/SEI 7-16.

B. Seismic Design Calculations:

1. Perform calculations to obtain force information necessary to properly select seismic-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7-16. Where "ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to in this subparagraph is the edition intended as reference throughout the Section Text.

a. Data indicated below to be determined by Delegated Design Contractor must be obtained by Contractor and must be included in individual component submittal packages.

b. Coordinate seismic design calculations with wind-load calculations for equipment mounted outdoors. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.

c. Building Occupancy Category: III.

d. Building Risk Category: III.

e. Building Site Classification: E.

f. Seismic Design Category: D.

2. Calculation Factors, ASCE/SEI 7-16, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-16 unless otherwise noted.

a. Horizontal Seismic Design Force F_p: Value is to be calculated by Delegated Design Contractor using Equation 13.3-1. Factors below must be obtained for this calculation:

1) S_{DS} = Spectral Acceleration: 0.297g. Value applies to all components on Project.

2) a_p = Component Amplification Factor: See Structural Drawing Schedule for each component.

3) I_p = Component Importance Factor: See Structural Drawing Schedule for each component.

4) W_p = Component Operating Weight: For each component. Obtain by Delegated-Design Contractor from each component submittal.

5) R_p = Component Response Modification Factor: See Structural Drawing Schedule for each component.

6) z = Height in Structure of Point of Attachment of Component for Base: Determine from Project Drawings for each component by Delegated-Design Contractor. For items at or below the base, "z" shall be taken as zero.

7) h = Average Roof Height of Structure for Base: Determine from Project Drawings by Delegated-Design Contractor.

b. Vertical Seismic Design Force: Calculated by Delegated Design Contractor using method explained in ASCE/SEI 7-16, Paragraph 13.3.1.2.

c. Seismic Relative Displacement D_{pI}: Calculated by Delegated Design Contractor using methods explained in ASCE/SEI 7-16, Paragraph 13.3.2. Factors below must be obtained for this calculation:

1) D_p = Relative Seismic Displacement that Each Component Must Be Designed to Accommodate: Calculated by Delegated-Design Contractor in accordance with ASCE/SEI 7-16, Paragraph 13.3.2.

2) I_e = Structure Importance Factor: 1.0. Value applies to all components on Project.

3) δ_{xA} = Deflection at Building Level x of Structure A: See Structural Drawing Schedule for each component.

4) δ_{yA} = Deflection at Building Level y of Structure A: See Structural Drawing Schedule for each component.

5) δ_{yB} = Deflection at Building Level y of Structure B: See Structural Drawing Schedule for each component.

6) h_x = Height of Level x to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.

7) h_y = Height of Level y to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.

8) Δ_{aA} = Allowable Story Drift for Structure A: See Structural Drawing Schedules for each component.

9) Δ_{aB} = Allowable Story Drift for Structure B: See Structural Drawing Schedules for each component.

10) h_{sx} = Story Height Used in the Definition of Allowable Drift Δ_a: See Drawings Schedules for each component.

d. Component Fundamental Period T_p: Calculated by Delegated Design Contractor using methods explained in ASCE/SEI 7-16, Paragraph 13.3.3. Factors below must be obtained for this calculation:

1) W_p = Component Operating Weight: Determined by Contractor from Project Drawings and manufacturer's data.

2) g = Gravitational Acceleration: 32.17 fps^2.

3) K_p = Combined Stiffness of Component, Supports, and Attachments: Determined by delegated design seismic engineer.

C. Wind-Load Design Calculations:

1. Perform calculations to obtain force information necessary to properly select wind-load-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7-16. Where "ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to in this subparagraph is intended as referenced throughout the Section Text unless otherwise noted.

a. Data indicated below that are specific to individual pieces of equipment must be obtained by Contractor and must be included in individual component submittal packages.

b. Coordinate design wind-load calculations with seismic load calculations for equipment requiring both seismic and wind-load reinforcement. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.

2. Design wind pressure "p" for rooftop equipment is to be calculated by Delegated Design Contractor using methods in ASCE/SEI 7-16, Ch. 30, PART 6: Building Appurtenances and Rooftop Structures and Equipment.

a. Risk Category: III.

b. h = Mean Roof Height: 0’-0”.

c. V = Basic Wind Speed: 120 mph.

d. K_d = Wind Directionality Factor: 0.85.

e. Exposure Category: C.

f. K_{zt} = Topographic Factor: 1.0.

g. K_e = Ground Elevation Factor: 1.0.

h. K_z = Velocity Pressure Exposure Coefficient (Evaluated at Height z): 0.85.

i. K_h = Velocity Pressure Exposure Coefficient (Evaluated at Height h): 0.85.

j. q_z = Velocity Pressure: Value calculated by delegated wind-load design Contractor using methods detailed in ASCE/SEI 7-16 Section 26.10.1 or other source approved by authorities having jurisdiction.

k. q_h = Velocity Pressure: Value calculated by delegated wind-load design Contractor using methods detailed in ASCE/SEI 7-16 Section 26.10.1 or other source approved by authorities having jurisdiction.

l. G = Gust-Effect Factor: 0.85.

m. Enclosure Classification: Enclosed Building.

n. GC_{pi} = Internal Pressure Coefficient: +/- 0.18.

D. Consequential Damage: Provide additional seismic restraints for suspended HVAC components or anchorage of floor-, roof-, or wall-mounted HVAC components as indicated in ASCE/SEI 7-16 so that failure of a non-essential or essential HVAC component will not cause failure of any other essential architectural, mechanical, or electrical building component.

E. Fire/Smoke Resistance: Seismic- and wind-load-restraint devices that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.

F. Component Supports:

1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.

2. All component support attachments must comply with force and displacement resistance requirements of ASCE/SEI 7-16 Section 13.6.

2.2 Elastomeric Isolation Pads

A. Elastomeric Isolation Pads:

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.

2. Size: Factory or field cut to match requirements of supported equipment.

3. Pad Material: Oil and water resistant with elastomeric properties. Neoprene rubber, silicone rubber, or other elastomeric material.

4. Surface Pattern: Smooth, ribbed, or waffle pattern.

5. Infused nonwoven cotton or synthetic fibers.

6. Load-bearing metal plates adhered to pads.

7. Sandwich-Core Material: Resilient and elastomeric.

   a. Surface Pattern: Smooth, ribbed, or waffle pattern.

   b. Infused nonwoven cotton or synthetic fibers.

2.3 Elastomeric Isolation Mounts

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Mounting Plates:

   a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.

b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

2. Elastomeric Material: Molded, oil- and water-resistant neoprene rubber, silicone rubber, or other elastomeric material.

2.4 Restrained Elastomeric Isolation Mounts

A. Restrained Elastomeric Isolation Mounts:

1. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

a. Housing: Cast-ductile iron or welded steel.

b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 Restraints - Rigid Type

A. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.6 Restraints - Cable Type

A. Seismic-Restraint Cables: ASTM A1023/A12023M galvanized or ASTM A603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.

B. Restraint cable assembly with cable fittings must comply with ASCE/SEI 19. All cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.7 Restraint Accessories

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Non-metallic stiffeners are unacceptable.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid restraints and restraint cables.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.8 Post-Installed Concrete Anchors

A. Mechanical Anchor Bolts:

1. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

B. Provide post-installed concrete anchors that have been prequalified for use in seismic applications. Post-installed concrete anchors must comply with all requirements of ASCE/SEI 7-16, Ch. 13.

1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.

C. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

Part 3 Execution

3.1 Applications

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static, wind load, and seismic loads within specified loading limits.

3.2 Installation Of Vibration-Control, Wind-Load Control, And Seismic-Restraint Devices

A. Provide vibration-control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Devices Schedules, where indicated on Drawings, or where Specifications indicate they are to be installed on specific equipment and systems.

B. Provide seismic-restraint and wind-load control devices for systems and equipment where indicated in Equipment Schedules or Seismic-Restraint Devices Schedules, where indicated on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

C. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 30 00 "Cast In Place Concrete."

D. Installation of vibration isolators, wind-load restraints, must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

E. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

2. Install seismic-restraint, and wind-load-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

F. Piping Restraints:

1. Comply with requirements in MSS SP-127.

2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.

3. Brace a change of direction longer than 12 feet.

G. Ductwork Restraints:

1. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." And ASCE/SEI 7.

2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.

3. Brace a change of direction longer than 12 feet.

4. Select seismic-restraint devices with capacities adequate to carry static and seismic loads.

5. Install cable restraints on ducts that are suspended with vibration isolators.

H. Install seismic- and wind-load-restraint cables so they do not bend across edges of adjacent equipment or building structure.

I. Install seismic- and wind-load-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

J. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

K. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

L. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

M. Mechanical Anchor Bolts:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors to be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Set anchors to manufacturer's recommended torque, using a torque wrench.

5. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.3 Adjusting

A. Adjust isolators after system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.4 Field Quality Control

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

B. Tests and Inspections:

1. Perform tests and inspections.

2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

3. Schedule test with Owner before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.

4. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.

5. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.

6. Test to 90 percent of rated proof load of device.

7. Measure isolator restraint clearance.

8. Measure isolator deflection.

C. Remove and replace malfunctioning units and retest as specified above.

D. Units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Equipment labels.

2. Warning signs and labels.

3. Duct labels.

1.2 Action Submittals

A. Product Data: For each type of product.

Part 2 Products

2.1 Equipment Labels

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch minimum thickness, with predrilled or stamped holes for attachment hardware.

2. Letter and Background Color: As indicated for specific application under Part 3.

3. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

4. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

5. Fasteners: Stainless steel rivets or self-tapping screws.

6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.

2. Letter and Background Color: As indicated for specific application under Part 3.

3. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.

4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

6. Fasteners: Stainless steel rivets or self-tapping screws.

7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

2.2 Warning Signs And Labels

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.

B. Letter and Background Color: As indicated for specific application under Part 3.

C. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.

D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

F. Fasteners: Stainless steel rivets or self-taping screws.

G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

H. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA70E.

I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 Duct Labels

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter and Background Color: As indicated for specific application under Part 3.

C. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

F. Fasteners: Stainless steel rivets or self-tapping screws.

G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

H. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings. Also include the following:

1. Duct size.

2. Flow-Direction Arrows: Include flow-direction arrows on main distribution ducts. Arrows may be either integral with label or may be applied separately.

3. Lettering Size: Size letters in accordance with ASME A13.1 for piping.

Part 3 Execution

3.1 Preparation

A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 Installation, General Requirements

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 Installation Of Equipment Labels, Warning Signs, And Labels

A. Permanently fasten labels on each item of mechanical equipment.

B. Sign and Label Colors:

1. White letters on an ANSI Z535.1 safety-blue background.

C. Locate equipment labels where accessible and visible.

D. Arc-Flash Warning Signs: Provide arc-flash warning signs on electrical disconnects and other equipment where arc-flash hazard exists, as indicated on Drawings, and in accordance with requirements of OSHA and NFPA 70E.

3.4 Installation Of Duct Labels

A. Install plastic-laminated duct labels showing service and flow direction with permanent adhesive on air ducts.

1. Provide labels in the following color codes:

a. For air supply ducts: White letters on blue background.

b. For air return ducts: White letters on blue background.

c. For exhaust-, outside-, relief-, return-, and mixed-air ducts: White letters on blue background.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Testing, Adjusting, and Balancing of Air Systems:

   a. Constant-volume air systems.

2. Testing, adjusting, and balancing of equipment.

3. Procedures for exhaust hoods.

4. Duct leakage tests verification.

5. UFAD plenum leakage tests verification.

6. HVAC-control system verification.

1.2 Definitions

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

F. TDH: Total dynamic head.

G. UFAD: Underfloor air distribution.

1.3 Informational Submittals

A. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

B. Certified TAB reports.

1.4 Quality Assurance

A. TAB Specialists Qualifications, Certified by AABC:

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.

2. TAB Technician: Employee of the TAB specialist and certified by AABC.

B. TAB Specialists Qualifications, Certified by NEBB or TABB:

1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.

2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB.

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

E. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

1.5 Field Conditions

A. Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

Part 2 Products (Not Applicable)

Part 3 Execution

3.1 Examination

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data, including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

G. Examine test reports specified in individual system and equipment Sections.

H. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

I. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.

J. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.

K. Examine operating safety interlocks and controls on HVAC equipment.

L. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

M. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 Preparation

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.

2. Strategies and step-by-step procedures for balancing the systems.

3. Instrumentation to be used.

4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.

b. Duct systems are complete with terminals installed.

c. Volume, smoke, and fire dampers are open and functional.

d. Clean filters are installed.

e. Fans are operating, free of vibration, and rotating in correct direction.

f. Variable-frequency controllers' startup is complete and safeties are verified.

g. Automatic temperature-control systems are operational.

h. Ceilings are installed.

i. Windows and doors are installed.

j. Suitable access to balancing devices and equipment is provided.

3.3 General Procedures for Testing and Balancing

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in AABC's "National Standards for Total System Balance" and in this Section.

B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.

2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 33 00 "Air Duct Accessories."

3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 23 07 13 "Duct Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 Testing, Adjusting, and Balancing of HVAC Equipment

A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:

1. Motors.
2. Fans and ventilators.
3. Terminal units.
4. Unit heaters.
5. Condensing units.
6. Air-handling units.
7. Heating and ventilating units.
8. Rooftop air-conditioning units.
9. Heating-only makeup air units.
10. Dedicated outdoor-air units.
11. Packaged air conditioners.
12. Self-contained air conditioners.
13. Computer-room air conditioners.
14. Split-system air conditioners.
15. Heat pumps.
16. Coils.
17. Unit ventilators.
18. Dehumidification units.

3.5 General Procedures for Balancing Air Systems

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' Record drawings duct layouts.

C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

D. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling-unit components.

3.6 Procedures for Constant-Volume Air Systems

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

   a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.

   b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.

   c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

2. Measure fan static pressures as follows:

   a. Measure static pressure directly at the fan outlet or through the flexible connection.

   b. Measure static pressure directly at the fan inlet or through the flexible connection.

   c. Measure static pressure across each component that makes up the air-handling system.

   d. Report artificial loading of filters at the time static pressures are measured.

3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.

4. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.

2. Adjust submain and branch duct volume dampers for specified airflow.

3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.

2. Measure inlets and outlets airflow.

3. Adjust each inlet and outlet for specified airflow.

4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.

2. Re-measure and confirm that total airflow is within design.

3. Re-measure all final fan operating data, speed, volts, amps, and static profile.

4. Mark all final settings.

5. Test system in economizer mode. Verify proper operation and adjust if necessary.

6. Measure and record all operating data.

7. Record final fan-performance data.

3.7 Procedures for Motors

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.8 Procedures for Air-Cooled Condensing Units

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of compressor(s), fan(s), and motors.

3.9 HVAC Controls Verification

A. In conjunction with system balancing, perform the following:

1. Verify HVAC control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.

6. Verify the operation of valve and damper actuators.

7. Verify that controlled devices are properly installed and connected to correct controller.

8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.

9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.10 Procedures for Testing, Adjusting, and Balancing Existing Systems

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan and equipment with fan(s).

2. Measure and record flows, temperatures, and pressures of each piece of equipment in each system. Compare the values to design or nameplate information, where information is available.

3. Measure motor voltage and amperage. Compare the values to motor nameplate information.

4. Check the refrigerant charge.

5. Check the condition of filters.

6. Check the condition of coils.

7. Check the operation of the drain pan and condensate-drain trap.

8. Check bearings and other lubricated parts for proper lubrication.

9. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. TAB After Construction: Before performing testing and balancing of renovated existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished in accordance with renovation scope indicated by Contract Documents. Verify the following:

1. New filters are installed.

2. Coils are clean and fins combed.

3. Drain pans are clean.

4. Fans are clean.

5. Bearings and other parts are properly lubricated.

6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.

2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.

3. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.

4. Balance each air outlet.

3.11 Tolerances

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent. If design value is less than 100 cfm, within 10 cfm.

2. Air Outlets and Inlets: Plus or minus 10 percent. If design value is less than 100 cfm, within 10 cfm.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.12 Progress Reporting

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance-measuring and -balancing devices.

B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.13 Final Report

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.

2. Include a list of instruments used for procedures, along with proof of calibration.

3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Fan curves.

2. Manufacturers' test data.

3. Field test reports prepared by system and equipment installers.

4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.

2. Name and address of the TAB specialist.

3. Project name.

4. Project location.

5. Architect's name and address.

6. Engineer's name and address.

7. Contractor's name and address.

8. Report date.

9. Signature of TAB supervisor who certifies the report.

10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.

11. Summary of contents, including the following:

    a. Indicated versus final performance.

    b. Notable characteristics of systems.

    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.

13. Data for terminal units, including manufacturer's name, type, size, and fittings.

14. Notes to explain why certain final data in the body of reports vary from indicated values.

15. Test conditions for fans performance forms, including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.

    b. Conditions of filters.

    c. Cooling coil, wet- and dry-bulb conditions.

    d. Heating coil, dry-bulb conditions.

    e. Face and bypass damper settings at coils.

    f. Fan drive settings, including settings and percentage of maximum pitch diameter.

    g. Settings for pressure controller(s).

    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.

2. Water and steam flow rates.

3. Duct, outlet, and inlet sizes.

4. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units, include the following:

1. Unit Data:

a. Unit identification.

b. Location.

c. Make and type.

d. Model number and unit size.

e. Manufacturer's serial number.

f. Unit arrangement and class.

g. Discharge arrangement.

h. Sheave make, size in inches, and bore.

i. Center-to-center dimensions of sheave and amount of adjustments in inches.

j. Number, make, and size of belts.

k. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.

b. Horsepower and speed.

c. Volts, phase, and hertz.

d. Full-load amperage and service factor.

e. Sheave make, size in inches, and bore.

f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.

b. Total system static pressure in inches wg.

c. Fan speed.

d. Inlet and discharge static pressure in inches wg.

e. For each filter bank, filter static-pressure differential in inches wg.

f. Preheat-coil static-pressure differential in inches wg.

g. Cooling-coil static-pressure differential in inches wg.

h. Heating-coil static-pressure differential in inches wg.

i. List for each internal component with pressure-drop, static-pressure differential in inches wg.

j. Outdoor airflow in cfm.

k. Return airflow in cfm.

l. Outdoor-air damper position.

m. Return-air damper position.

n. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.

b. Location.

c. Coil type.

d. Number of rows.

e. Fin spacing in fins per inch o.c.

f. Make and model number.

g. Face area in sq. ft.

h. Tube size in NPS.

i. Tube and fin materials.

j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.

b. Average face velocity in fpm.

c. Air pressure drop in inches wg.

d. Outdoor-air, wet- and dry-bulb temperatures in deg F.

e. Return-air, wet- and dry-bulb temperatures in deg F.

f. Entering-air, wet- and dry-bulb temperatures in deg F.

g. Leaving-air, wet- and dry-bulb temperatures in deg F.

h. Water flow rate in gpm.

i. Water pressure differential in feet of head or psig.

j. Entering-water temperature in deg F.

k. Leaving-water temperature in deg F.

l. Refrigerant expansion valve and refrigerant types.

m. Refrigerant suction pressure in psig.

n. Refrigerant suction temperature in deg F.

o. Inlet steam pressure in psig.

G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.

b. Location.

c. Coil identification.

d. Capacity in Btu/h.

e. Number of stages.

f. Connected volts, phase, and hertz.

g. Rated amperage.

h. Airflow rate in cfm.

i. Face area in sq. ft.

j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

   a. Heat output in Btu/h.

   b. Airflow rate in cfm.

   c. Air velocity in fpm.

   d. Entering-air temperature in deg F.

   e. Leaving-air temperature in deg F.

   f. Voltage at each connection.

   g. Amperage for each phase.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

   a. System identification.

   b. Location.

   c. Make and type.

   d. Model number and size.

   e. Manufacturer's serial number.

   f. Arrangement and class.

   g. Sheave make, size in inches, and bore.

   h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

   a. Motor make, and frame type and size.

   b. Horsepower and speed.

   c. Volts, phase, and hertz.

   d. Full-load amperage and service factor.

   e. Sheave make, size in inches, and bore.

   f. Center-to-center dimensions of sheave and amount of adjustments in inches.

g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.

b. Total system static pressure in inches wg.

c. Fan speed.

d. Discharge static pressure in inches wg.

e. Suction static pressure in inches wg.

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System fan and air-handling-unit number.

b. Location and zone.

c. Traverse air temperature in deg F.

d. Duct static pressure in inches wg.

e. Duct size in inches.

f. Duct area in sq. ft.

g. Indicated airflow rate in cfm.

h. Indicated velocity in fpm.

i. Actual airflow rate in cfm.

j. Actual average velocity in fpm.

k. Barometric pressure in psig.

J. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.

b. Location and zone.

c. Apparatus used for test.

d. Area served.

e. Make.

f. Number from system diagram.

g. Type and model number.

h. Size.

i. Effective area in sq. ft.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.

b. Air velocity in fpm.

c. Preliminary airflow rate as needed in cfm.

d. Preliminary velocity as needed in fpm.

e. Final airflow rate in cfm.

f. Final velocity in fpm.

g. Space temperature in deg F.

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.

b. Location and zone.

c. Room or riser served.

d. Coil make and size.

e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.

b. Entering-water temperature in deg F.

c. Leaving-water temperature in deg F.

d. Water pressure drop in feet of head or psig.

e. Entering-air temperature in deg F.

f. Leaving-air temperature in deg F.

L. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.

b. Serial number.

c. Application.

d. Dates of use.

e. Dates of calibration.

3.14 Verification of Tab Report

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Owner.

B. Owner shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the TAB shall be considered incomplete and shall be rejected.

E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes shall be tracked to show changes made to previous report.

2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.

F. Prepare test and inspection reports.

3.15 Additional Tests

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

Part 1 General

1.1 Summary

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposedd supply and outdoor air.
3. Outdoor, exposed supply and return.

1.2 Action Submittals

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

Part 2 Products

2.1 Performance Requirements

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 Insulation Materials

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials are applied.

B. Products do not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.

F. Glass-Fiber Blanket: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 450 deg F in accordance with ASTM C411. Comply with ASTM C553, Type II, and ASTM C1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

G. Mineral Wool Blanket: Basalt volcanic rock-derived fibers bonded with a thermosetting resin, unfaced; suitable for maximum use temperature up to 1200 deg F in accordance with ASTM C447. Comply with ASTM C553.

H. Glass-Fiber Board Insulation: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F and 250 deg F for jacketed and between 35 deg F and 450 deg F for unfaced in accordance with ASTM C411. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Mineral Wool Board: Basalt volcanic rock-derived fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 1100 deg F in accordance with ASTM C411. Comply with ASTM C612, Type III, unfaced.

2.3 Adhesives

A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

C. FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

2.4 Mastics and Coatings

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.

2. Service Temperature Range: Minus 20 to plus 180 deg F.

3. Comply with MIL-PRF-19565C, Type II, for permeance requirements.

4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm at manufacturer's recommended dry film thickness.

2. Service Temperature Range: Minus 20 to plus 180 deg F.

3. Color: White.

2.5 Sealants

A. FSK and Metal Jacket Flashing Sealants:

1. Materials are compatible with insulation materials, jackets, and substrates.

2. Fire- and water-resistant, flexible, elastomeric sealant.

3. Service Temperature Range: Minus 40 to plus 250 deg F.

4. Color: Aluminum.

2.6 Factory-Applied Jackets

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.7 Field-Applied Fabric-Reinforcing Mesh

A. Woven Polyester Mesh: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

2.8 Securements

A. Aluminum Bands: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.

c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.

c. Adhesive-backed base with a peel-off protective cover.

3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

4. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

Part 3 Execution

3.1 Preparation

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.2 General Installation Requirements

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

   1. Install insulation continuously through hangers and around anchor attachments.

   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

   1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.

   2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.3 Penetrations

A. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.

4. Seal jacket to wall flashing with flashing sealant.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

D. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to

match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.

2. Seal penetrations through fire-rated assemblies.

3.4 Installation of Glass-Fiber and Mineral-Wool Insulation

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

B. Comply with manufacturer's written installation instructions.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

d. Do not overcompress insulation during installation.

e. Impale insulation over pins and attach speed washers.

f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

C. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints.

Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

d. Do not overcompress insulation during installation.

e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.5 Field-Applied Jacket Installation

A. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.6 Duct Insulation Schedule, General

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.

2. Indoor, exposed supply and outdoor air.

3. Outdoor, exposed supply and return.

B. Items Not Insulated:

1. Fibrous-glass ducts.

2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.

3. Factory-insulated flexible ducts.

4. Factory-insulated plenums and casings.

5. Flexible connectors.

6. Vibration-control devices.

7. Factory-insulated access panels and doors.

3.7 Indoor Duct and Plenum Insulation Schedule

A. Concealed, Supply-Air and Outdoor-Air Duct and Plenum Insulation: Glass-fiber or Mineral wool blanket, R-6 minimum.

B. Exposed, Supply-Air and Outdoor-Air Duct and Plenum Insulation: Glass-fiber or Mineral wool blanket, R-6 minimum.

3.8 Aboveground, Outdoor Duct and Plenum Insulation Schedule

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.

B. Outdoor, Supply-Air and Plenum Insulation: Glass-fiber board, R-8 minimum.

3.9 Outdoor, Field-Applied Jacket Schedule

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Aluminum, Smooth: 0.016 inch thick.

D. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. Aluminum, Smooth with 1-1/4-Inch- Deep Corrugations: 0.032 inch thick.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.

Part 2 Products

2.1 Performance Requirements

A. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

D. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 Single-Wall Rectangular Ducts And Fittings

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to weather and located in corrosive environments, construct of Type 304 or Type 316 stainless steel indicated by manufacturer to be suitable for installation. Refer to plans for locations of corrosive environments and required materials in these areas.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.

2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 Single-Wall Round Ducts And Fittings

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.

2. For ducts exposed to weather and located in corrosive environments, construct of Type 304 or Type 316 stainless steel indicated by manufacturer to be suitable for installation. Refer to plans for locations of corrosive environments and required materials in these areas.

B. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 Sheet Metal Materials

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

   1. Galvanized Coating Designation: G60.

   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

   1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Galvanized steel, 1/4-inch- minimum diameter for lengths 36 inches or less; 3/8-inch- minimum diameter for lengths longer than 36 inches.

2.5 Sealant And Gaskets

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/ silicone activator to react exothermically with tape to form hard, durable, airtight seal.

2. Tape Width: 3 inches.

3. Sealant: Modified styrene acrylic.

4. Water resistant.

5. Mold and mildew resistant.

6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.

7. Service: Indoor and outdoor.

8. Service Temperature: Minus 40 to plus 200 deg F.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.

2. Solids Content: Minimum 65 percent.

3. Shore A Hardness: Minimum 20.

4. Water resistant.

5. Mold and mildew resistant.

6. VOC: Maximum 75 g/L (less water).

7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.

8. Service: Indoor or outdoor.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.

2. Type: S.

3. Grade: NS.

4. Class: 25.

5. Use: O.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.

2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.

3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 Hangers And Supports

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A492.

F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

Part 3 Execution

3.1 Duct Installation

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation.

M. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

N. Branch Connections: Use lateral or conical branch connections.

3.2 Installation Of Exposed Ductwork

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 Additional Installation Requirements For Laboratory Exhaust And Fume Hood Exhaust Ducts

A. Install ducts in accordance with NFPA 45, "Fire Protection for Laboratories Using Chemicals."

B. Install exhaust ducts without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to hood or inlet. Where indicated on Drawings, install trapped drain piping.

C. Connect duct to fan, fume hood, and other equipment indicated on Drawings.

3.4 Ductwork Exposed To Weather

A. All external joints are to be welded or have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Single Wall:

1. Ductwork shall be Type 304 or Type 316 stainless steel.

2. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 23 07 13 "Duct Insulation."

3.5 Duct Sealing

A. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2. Outdoor, Supply-Air Ducts: Seal Class A.

3. Outdoor, Return-Air Ducts: Seal Class C.

4. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.

5. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.

6. Unconditioned Space, Exhaust Ducts: Seal Class C.

7. Unconditioned Space, Return-Air Ducts: Seal Class B.

8. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.

9. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.

10. Conditioned Space, Exhaust Ducts: Seal Class B.

11. Conditioned Space, Return-Air Ducts: Seal Class C.

3.6 Hanger And Support Installation

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.

2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.

4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.7 Connections

A. Make connections to equipment with flexible connectors complying with Section 23 33 00 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 Field Quality Control

A. Perform tests and inspections.

B. Leakage Tests: For ducts in a pressure class of 3-inch w.g. and higher. Typical for medium pressure VAV systems.

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.

2. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

3. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.

4. Test for leaks before applying external insulation.

5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.

6. Give seven days' advance notice for testing.

C. Duct system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 Duct Cleaning

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use duct cleaning methodology as indicated in NADCA ACR.

C. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 23 33 00 "Air Duct Accessories" for access panels and doors.

2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.

3. Remove and reinstall ceiling to gain access during the cleaning process.

D. ulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.

2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

E. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).

2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.

3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.

4. Coils and related components.

5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.

6. Supply-air ducts, dampers, actuators, and turning vanes.

7. Dedicated exhaust and ventilation components and makeup air systems.

F. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.

3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.

4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

6. Provide drainage and cleanup for wash-down procedures.

7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.10 Startup

A. Air Balance: Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

3.11 Duct Schedule

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

2. Underground Ducts: Concrete-encased, stainless steel.

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive 1-inch wg.

b. Minimum SMACNA Seal Class: A.

c. SMACNA Leakage Class for Rectangular: 12.

d. SMACNA Leakage Class for Round: 12.

2. Ducts Connected to Constant-Volume Air-Handling Units:

a. Pressure Class: Positive 2-inch wg.

b. Minimum SMACNA Seal Class: A.

c. SMACNA Leakage Class for Rectangular: 6.

d. SMACNA Leakage Class for Round: 6.

3. Ducts Connected to Variable-Air-Volume Air-Handling Units:

a. Pressure Class: Positive 3-inch wg.

b. Minimum SMACNA Seal Class: A.

c. SMACNA Leakage Class for Rectangular: 3.

d. SMACNA Leakage Class for Round: 3.

C. Return and Exhaust Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 1-inch wg.

b. Minimum SMACNA Seal Class: A.

c. SMACNA Leakage Class for Rectangular: 12.

d. SMACNA Leakage Class for Round: 12.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.

b. Minimum SMACNA Seal Class: A.

c. SMACNA Leakage Class for Rectangular: 6.

d. SMACNA Leakage Class for Round: 6.

D. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 1-inch wg.

b. Minimum SMACNA Seal Class: A.

c. SMACNA Leakage Class for Rectangular: 12.

d. SMACNA Leakage Class for Round: 12.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.

b. Minimum SMACNA Seal Class: A.

c. SMACNA Leakage Class for Rectangular: 6.

d. SMACNA Leakage Class for Round: 6.

E. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.

2. Stainless-Steel Ducts:

   a. Exposed to Airstream: Match duct material.

   b. Not Exposed to Airstream: Match duct material.

3. Aluminum Ducts: Aluminum.

F. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

   a. Velocity 1000 fpm or Lower:

      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.

   b. Velocity 1000 to 1500 fpm:

      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.

   c. Velocity 1500 fpm or Higher:

      1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

      1) Velocity 1000 fpm or Lower: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.

      2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.

      3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

      4) Radius-to Diameter Ratio: 1.5.

   b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.

c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or Welded.

G. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.

b. Rectangular Main to Round Branch: Conical spin in.

2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm or Lower: 90-degree tap.

b. Velocity 1000 to 1500 fpm: Conical tap.

c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Fibrous-glass ducts and fittings.

B. Related Requirements:

1. Section 23 31 13 – Metal Ducts.

1.2 Action Submittals

A. Product Data: For each type of the following products:

1. Fibrous-glass duct materials.

1.3 Quality Assurance

A. Hanger and Support Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for steel hangers and supports.

2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum hangers and supports.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

Part 2 Products

2.1 Performance Requirements

A. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions to comply with ASCE/SEI 7.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1, Section 5.4 - "Airstream Surfaces."

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

E. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

2.2 Fibrous-Glass Ducts and Fittings

A. Fibrous-Glass Duct Materials: Resin-bonded fiberglass, faced on the outside surface with fire-resistive FSK vapor retarder and with a smooth fiberglass mat finish on the air-side surface.

1. Duct Board: Factory molded into rectangular boards, or round segments.

2. Temperature Limits: 40 to 250 deg F (5 to 121 deg C) inside ducts; 150 deg F (66 deg C) ambient temperature surrounding ducts.

3. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F (0.035 W/m x K) at 75 deg F (24 deg C) mean temperature.

4. Moisture Absorption: Not exceeding 5 percent by weight at 120 deg F (49 deg C) and 95 percent relative humidity for 96 hours when tested according to ASTM C1104/C1104M.

5. Acoustical Performance: Conform to sound absorption coefficients listed in NAIMA AH116.

6. Permeability: 0.02 perms (1.15 ng/Pa x s x sq. m) maximum when tested according to ASTM E96/E96M, Procedure A.

7. Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C423, Mounting A.

8. Required Markings: EI stiffness rating, UL label, and other markings required by UL 181 on each full sheet of duct board.

B. Closure Materials:

1. Mold and mildew resistant.

2. Two-Part Tape Sealing System: Comply with UL 181A; imprinted by manufacturer with coding "181A-M," manufacturer's name, and a date code.

a. Tape: Woven glass fiber impregnated with mineral gypsum.

b. Minimum Tape Width: 3 inches (76 mm).

c. Sealant: Modified styrene acrylic.

d. Water resistant.

e. Mold and mildew resistant.

C. Fabrication:

1. Comply with: SMACNA's "Fibrous Glass Duct Construction Standards," Ch. 3, "Specifications and Closure," and Ch. 4, "Fittings and Connections" for the following:

a. Joints, seams, transitions, elbows, and branch connections.

b. Reinforcements, including channel and tie rod reinforcement materials, spacing, and fabrications.

2. Fabricate 90-degree mitered elbows to include turning vanes.

D. Reinforcements: Comply with requirements in SMACNA's "Fibrous Glass Duct Construction Standards," Ch. 5, "Reinforcement" for channel- and tie-rod reinforcement materials, spacing, and fabrication.

2.3 Hangers and Supports

A. Hanger Rods for Corrosive Environments: Type 316 stainless steel.

B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes complying with ASTM A36/A36M.

Part 3 Execution

3.1 Duct Installation

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install duct sections in maximum practical lengths with fewest possible joints.

C. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

D. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

E. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

F. Where ducts pass through non-fire-rated interior partitions and exterior walls, and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

G. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

H. Elbows: Use long-radius elbows unless otherwise noted on drawings.

I. Branch Connections: Use lateral or conical branch connections.

J. Install fibrous-glass ducts and fittings to comply with SMACNA's "Fibrous Glass Duct Construction Standards."

K. Air Balance: Comply with requirements in Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC.

3.2 Hanger and Support Installation

A. Install hangers and supports for fibrous-glass ducts and fittings to comply with SMACNA's "Fibrous Glass Duct Construction Standards," Ch. 6, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

2. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.

3. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

C. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 Duct Schedule

A. Indoor Ducts and Fittings:

1. Fibrous-Glass Rectangular and Round Ducts and Fittings:

a. Minimum Flexural Rigidity: EI-475.

b. Minimum Board Thickness: 1 inch (25 mm).

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Backdraft dampers.
2. Manual volume dampers.
3. Control dampers.
4. Flange connectors.
5. Flexible connectors.
6. Duct accessory hardware.

1.2 Action Submittals

A. Product Data: For each type of product.

Part 2 Products

2.1 Performance Requirements

A. Comply with NFPA 90A and NFPA 90B.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 Backdraft Dampers

A. Description: Gravity balanced.

B. Performance:

1. Maximum Air Velocity: 1250 fpm.
2. Maximum System Pressure: 1 inch wg.
3. Leakage:
   a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.

C. Construction:

1. Frame:

a. Hat shaped.

b. 16-gauge- thick, galvanized sheet steel with welded or mechanically attached corners and mounting flange.

c. 316 stainless steel for corrosive environments.

2. Blades:

a. Multiple single-piece blades.

b. Center pivoted, maximum 6-inch (150-mm) width, 16-gauge- thick, galvanized sheet steel with sealed edges.

c. 316 stainless steel for corrosive environments.

3. Blade Action: Parallel.

D. Blade Seals: Felt.

E. Blade Axles:

1. Material: Galvanized steel. 316 stainless steel for corrosive environments.

2. Diameter: 0.20 inch.

F. Tie Bars and Brackets: Aluminum.

G. Return Spring: Adjustable tension.

H. Bearings: Steel ball or synthetic pivot bushings.

I. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.

2. Counterweights and spring-assist kits for vertical airflow installations.

3. Chain pulls.

4. Screen Mounting:

a. Front mounted in sleeve.

1) Sleeve Thickness: 20 gauge (1.0 mm) minimum.

2) Sleeve Length: 6 inches (150 mm) minimum.

5. Screen Material: Aluminum.

6. Screen Type: Bird.

7. 90-degree stops.

2.3 Manual Volume Dampers

A. Standard, Steel, Manual Volume Dampers:

1. Performance:

    a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. (203 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.

2. Construction:

    a. Linkage out of airstream.

    b. Suitable for horizontal or vertical airflow applications.

3. Frames:

    a. Hat-shaped, 16-gauge- (1.6-mm-) thick, galvanized sheet steel.

    b. Hat-shaped, 316 stainless steel for corrosive environments.

    c. Mitered and welded corners.

    d. Flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:

    a. Multiple or single blade.

    b. Parallel- or opposed-blade design.

    c. Stiffen damper blades for stability.

    d. Galvanized steel; 16 gauge (1.6 mm) thick.

    e. 316 stainless steel for corrosive environments.

5. Blade Axles: Galvanized steel. 316 stainless steel for corrosive environments.

6. Bearings:

    a. Oil-impregnated bronze.

b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.

7. Tie Bars and Brackets: Aluminum.

8. Locking device to hold damper blades in a fixed position without vibration.

2.4 Control Dampers

A. General Requirements:

1. Unless otherwise indicated, use parallel-blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.

2. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.

B. Construction:

1. Linkage out of airstream.

2. Suitable for horizontal or vertical airflow applications.

3. Frames:

a. Hat, U, or angle shaped.

b. 16-gauge- (1.6-mm-) thick, galvanized sheet steel.

c. 316 stainless steel for corrosive environments.

d. Mitered and welded corners.

e. Flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:

a. Multiple blade with maximum blade width of 6 inches (150 mm).

b. Parallel and opposed-blade design.

c. Galvanized steel.

d. 316 stainless steel for corrosive environments.

e. 16-gauge- (1.6-mm-) thick single skin.

5. Blade Edging Seals:

    a. Replaceable Closed-cell neoprene.

6. Blade Jamb Seal: Flexible stainless steel, compression type.

7. Blade Axles: 1/2-inch (13-mm) diameter; galvanized steel.

8. Blade-Linkage Hardware: Zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of air stream.

9. Bearings:

    a. Oil-impregnated bronze.

    b. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.

2.5 Flange Connectors

A. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gauge and Shape: Match connecting ductwork.

2.6 Flexible Connectors

A. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Materials: Flame-retardant or noncombustible fabrics.

D. Coatings and Adhesives: Comply with UL 181, Class 1.

E. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.

F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).

2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.

3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

2.7 Duct Accessory Hardware

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.8 Materials

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G60 (Z180).

2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 316, and having a No. 2 finish for ducts in corrosive environments.

C. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B221 (ASTM B221M), Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum.

F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

Part 3 Execution

3.1 Installation

A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.

E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.

2. Install stainless steel volume dampers in stainless steel ducts.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.

H. Install flexible connectors to connect ducts to equipment.

I. Install duct test holes where required for testing and balancing purposes.

3.2 Field Quality Control

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.

2. Inspect turning vanes for proper and secure installation and verify that vanes do not move or rattle.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Backward-inclined centrifugal fans, including airfoil and curved blade fans.

1.2 Action Submittals

A. Product Data: For each type of product.

1.3 Closeout Submittals

A. Operation and maintenance data.

Part 2 Products

2.1 Performance Requirements

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.2 Backward-Inclined Centrifugal Fans

A. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, direct-driven centrifugal fans, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.

2. See mechanical schedule.

B. Motor Enclosure: Totally enclosed, air over.

C. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.

2. Companion Flanges: Rolled flanges for duct connections of same material as housing.

2.3 Motors

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors.

2.4 Source Quality Control

A. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.

B. AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.

C. Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

Part 3 Execution

3.1 Installation, General

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Support duct-mounted and other hanging centrifugal fans directly from the building structure, using suitable hanging systems as specified in Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.

E. Unit Support: Install centrifugal fans level on structural. Coordinate with duct connections. Secure units to structural support with anchor bolts.

F. Install units with clearances for service and maintenance.

3.2 Ductwork And Piping Connections

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00 - Air Duct Accessories.

B. Install ducts adjacent to fans to allow service and maintenance.

3.3 Electrical Connections

A. Connect wiring according to Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables.

B. Ground equipment according to Section 26 05 26 - Grounding and Bonding for Electrical Systems.

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 Control Connections

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 26 05 23 - Control-Voltage Electrical Power Cables.

3.5 Startup Service:

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.

2. Verify that shipping, blocking, and bracing are removed.

3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

4. Verify that cleaning and adjusting are complete.

5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.

6. Adjust damper linkages for proper damper operation.

7. Verify lubrication for bearings and other moving parts.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

9. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.

10. Shut unit down and reconnect automatic temperature-control operators.

11. Remove and replace malfunctioning units and retest as specified above.

3.6 Adjusting

A. Adjust damper linkages for proper damper operation.

B. Lubricate bearings.

C. Comply with requirements in Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC.

3.7 Cleaning

A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.8 Field Quality Control

A. Testing Agency: Contractor will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3. Fans and components will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.9 Demonstration

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes: Packaged terminal air-conditioners, outdoor, wall-mounted units.

1.2 Action Submittals

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

1.3 Closeout Submittals

A. Operation and maintenance data.

1.4 Warranty

A. Special Warranty: Manufacturer agrees to repair or replace components of packaged terminal air conditioners that fail in materials or workmanship within specified warranty period.

Part 2 Products

2.1 Packaged Terminal Air-Conditioners, Outdoor, Wall-Mounted Units

A. Description: Factory-assembled and -tested, self-contained, packaged, terminal air conditioner with room cabinet, electric refrigeration system, heating, and temperature controls; fully charged with refrigerant and filled with oil; with hardwired chassis and circuit breaker.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

2.2 Chassis

A. Cabinet: Sloped top, 0.052-inch-minimum thick steel with removable front panel with concealed latches.

1. Mounting: On exterior wall.

2. Discharge Grille: Extruded-aluminum discharge grille.

3. Return Grille: Extruded-aluminum grille.

4. Louvers: Extruded aluminum with enamel finish.

5. Finish: Epoxy coating.

6. Access Door: Hinged door in top of cabinet for access to controls.

7. Cabinet Extension: Matching cabinet in construction and finish, allowing diversion of airflow to adjoining room; with grille.

8. Insulation: Cooling and heating sections fully insulated with 1-inch-thick fiberglass insulation.

9. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Refrigeration System: Direct-expansion indoor coil with capillary restrictor and hermetically sealed scroll compressor with vibration isolation, and overload protection.

1. Indoor and Outdoor Coils: Seamless copper tubes mechanically expanded into aluminum fins.

C. Indoor Fan: Forward curved, centrifugal; with motor and positive-pressure ventilation damper with electric operator.

D. Filters: Disposable 2” MERV 8 filters.

E. Condensate Drain: Coated galvanized-steel drain pan. Drain to outdoor through base.

1. Comply with ASHRAE 62.1 for drain pan construction and connections.

2. Indoor and Outdoor Fan Motors: Two speed; comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 – Common Motor Requirements For HVAC Equipment.

a. Fan Motors: Permanently lubricated split capacitor.

b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.3 Heating

A. Electric-Resistance Heating Coil: Nickel-chromium-wire, electric-resistance heating elements with contactor and high-temperature-limit switch.

2.4 Controls

A. Control Module: Unit-mounted digital panel with touchpad temperature control and with touchpad for heating, cooling, and fan operation. Include the following features:

1. Low-Ambient Lockout Control: Prevents cooling-cycle operation below 40 deg F outdoor air temperature.

2. Reverse-Cycle Defrost: Solid-state sensor monitors frost buildup on outdoor coil and reverses unit to melt frost.

B. Remote Control: Standard unit-mounted controls with remote-mounted, low-voltage, adjustable thermostat with heat anticipator; heat-off-cool-auto switch; and on-auto fan switch.

C. Outdoor Air:

1. Motorized intake damper. Open intake when unit indoor-air fan runs.

2. Manual intake damper.

2.5 Capacities And Characteristics

A. Refer to drawings.

2.6 Source Quality Control

A. Sound-Power Level Ratings: Factory test to comply with AHRI 300, "Sound Rating and Sound Transmission Loss of Packaged Terminal Equipment."

B. Unit Performance Ratings: Factory test to comply with AHRI 310/380/CSA C744, "Packaged Terminal Air-Conditioners and Heat Pumps."

Part 3 Execution

3.1 Installation

A. Install units level and plumb, maintaining manufacturer's recommended clearances and tolerances.

B. Install wall sleeves in finished wall assembly; seal and weatherproof.

C. Install and anchor wall sleeves to withstand, without damage to equipment and structure, seismic forces required by building code.

3.2 Field Quality Control

A. Tests and Inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.

2. After installing packaged, terminal air conditioners and after electrical circuitry has been energized, test for compliance with requirements.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Packaged, terminal air conditioners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION

Part 1 General

1.1 Summary

A. This Section includes general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:

1. Submittals.
2. Coordination drawings.
3. Record documents.
4. Maintenance manuals.
5. Rough-ins.
6. Electrical installations.
7. Cutting and patching.

B. Related Sections: The following sections contain requirements that relate to this section:

1. Section 26 05 00 - Basic Electrical Materials and Methods, for materials and methods common to the remainder of Division 26.

1.2 Scope of Work

A. The general scope of the work of this project is the electrical construction associated with the Macon Lower Poplar Influent PS Wastewater Treatment Plant. The extent of the work is indicated on the Drawings and described herein. The materials and methods shall be specified as herein.

1.3 Submittals

A. General: Follow the procedures specified in Section 01 33 00 - Submittal Procedures.

B. Do not combine submittals of multiple Section under the same transmittal. Combined submittals will be returned marked “Not Reviewed.”

1.4 Record Documents

A. Prepare record documents in accordance with the requirements in Section 01 78 23 - Operation and Maintenance Data. In addition to the requirements specified in Division 1, indicate installed conditions for:

1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.

2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.

3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.5 Maintenance Manuals

A. Prepare maintenance manuals in accordance with Section 01 78 23 - Operation And Maintenance Data. In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions and lubrication charts and schedules.

1.6 Delivery, Storage, and Handling

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

Part 2 Products

2.1 Electrical Materials

A. Provide all materials used in this work, unless otherwise indicated, that are new and free from flaws or imperfections.

Part 3 Execution

3.1 Rough-In

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

3.2 Electrical Installations

A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, and materials installation with other building and site components. Electrical drawings are generally of a diagrammatic nature. Except where dimensioned locations are shown, plan and coordinate the work to eliminate interferences with other trades. Provide all necessary raceway offsets, fittings, and boxes; adjust all fixture and equipment locations and provide all supporting materials required for a planned, coordinated and neat installation. Where interferences occur, the Owner's authorized representative will decide which items must be relocated regardless of which was installed first.

2. Verify all dimensions by field measurements.

3. Provide chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.

4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building or pouring of concrete.

6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

7. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Owner's Representative.

8. Install systems, materials, and equipment level and plumb, parallel, and perpendicular to other building systems and components, where installed exposed in finished spaces.

9. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

10. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

3.3 Cutting and Patching

A. General:

1. Perform cutting, fitting, and patching of electrical equipment and materials required to:

    a. Uncover Work to provide for installation of ill-timed Work.

    b. Remove and replace defective Work.

    c. Remove and replace Work not conforming to requirements of the Contract Documents.

    d. Remove samples of installed Work as specified for testing.

    e. Install equipment and materials in existing structures.

    f. Upon instructions from the Owner's Representative, uncover and restore Work to provide for Owner's Representative's observation of concealed Work.

2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.

3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

5. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

6. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

7. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

3.4 Painting

A. Paint exposed electrical equipment and materials. Limit painting of factory-finished equipment to touching up unless specified otherwise.

END OF SECTION

Part 1 General

1.1 Summary

A. This Section includes limited scope general construction materials and methods for application with electrical installations as follows:

1. Miscellaneous metals for support of electrical materials and equipment.

2. Joint sealers for sealing around electrical materials and equipment; and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.

1.2 Submittals

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Welder certificates, signed by Contractor, certifying that welders comply with requirements specified under "Quality Assurance" article of this Section.

C. Schedules indicating proposed methods and sequence of operations for selective demolition prior to commencement of Work. Include coordination for shut-off of electrical service, and details for dust and noise control.

1. Coordinate sequencing with construction phasing and Owner occupancy.

1.3 Quality Assurance

A. Installer Qualifications: Engage an experienced Installer for the installation and application joint sealers.

B. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."

1.4 Delivery, Storage, and Handling

A. Deliver joint sealer materials in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

B. Store and handle joint sealer materials in compliance with the manufacturers' recommendations to prevent their deterioration and damage.

1.5 Project Conditions

A. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits permitted by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.

1.6 Sequence and Scheduling

A. Coordinate the shut-off and disconnection of electrical service with the owner.

B. Coordinate start-up of new equipment with the owner and process equipment installer.

Part 2 Products

2.1 Miscellaneous Metals

A. Steel plates, shapes, bars, and bar grating: ASTM A 36.

B. Cold-Formed Steel Tubing: ASTM A 500.

C. Hot-Rolled Steel Tubing: ASTM A 501.

D. Steel Pipe: ASTM A 53, Schedule 40, welded.

E. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout, recommended for interior and exterior applications.

F. Fasteners: Zinc-coated, type, grade, and class as required.

2.2 Fire Resistant Joint Sealers

A. Manufacturers

1. Hilti Construction Chemicals, Inc.

2. Dow Corning Corporation.

3. 3M, Construction Markets.

B. Materials

1. Firestopping Material: Single or multiple component silicone elastomeric compound as follows:

   a. Firestop Sealant: An adhesive, one part, silicone based, elastomeric sealant.

1) Hilti: CS 240 firestop sealant.

2) Dow Corning: Firestop sealant.

3) 3M: Fire barrier CP 25WB caulk.

b. Intumescent Wrap: An aluminum foil backed intumescent strip for plastic, insulated pipe, or other combustible penetrating items.

1) Hilti: CS 2420 intumescent wrap.

2) Dow Corning: Fire stop intumescent wrap, Strip 2002.

3) 3M: 3M Brand Fire Barrier FS-195 Wrap/Strip.

Part 3 Execution

3.1 Examination

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation and application of joint sealers and access panels. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 Preparation for Joint Sealers

A. Surface Cleaning for Joint Sealers: Clean surfaces of joints immediately before applying joint sealers to comply with recommendations of joint sealer manufacturer.

B. Apply joint sealer primer to substrates as recommended by joint sealer manufacturer. Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.

3.3 Erection of Metal Supports and Anchorage

A. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

B. Field Welding: Comply with AWS "Structural Welding Code."

3.4 Application of Joint Sealers

A. General: Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.

B. Tooling: Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

C. Installation of Fire-Stopping Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

END OF SECTION

Part 1 General

1.1 Summary

A. This Section covers the general and administrative requirements for testing of electrical systems, materials, and equipment.

1. The Contractor shall engage the services of a recognized independent testing firm for the purpose of performing inspections and tests as herein specified and in other Division 26 Sections. The Contractor shall submit the name and qualifications of the testing firm to the Owner for approval within 30 days after Notice to Proceed. This testing is not under the materials and testing allowance and shall be included in the contractors bid price.

2. The testing firm shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections.

3. It is the purpose of these specifications to ensure that all tested electrical equipment is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.

4. The tests and inspections shall determine suitability for energization.

5. Refer to individual Division 26 Sections for equipment and systems to be tested and detailed test requirements.

1.2 Quality Assurance

A. Testing Firm

1. The testing firm shall be an 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 utilize technicians who are regularly employed by the firm for testing services.

4. The testing firm shall submit proof of the above qualifications for approval from the Engineer.

B. Suitability of Test Equipment

1. All test equipment shall be in good mechanical and electrical condition.

2. Field test metering used to check power system meter calibration must have an accuracy higher than that of the instrument being checked.

3. Accuracy of metering in test equipment shall be appropriate for the test being performed but not in excess of 2 percent of the scale used.

4. Waveshape and frequency of test equipment output waveforms shall be appropriate for the test and tested equipment.

C. Test Instrument Calibration

1. The accuracy shall be directly traceable to the National Institute of Standards and Technology (NIST).

2. Instruments shall be calibrated in accordance with the following frequency schedule:

   a. Field Instruments: Analog, 6 months maximum; Digital, 12 months maximum

   b. Laboratory Instruments: 12 months

   c. Leased Specialty Equipment: 12 months where accuracy is guaranteed.

3. Dated calibration labels shall be visible on all test equipment.

4. Records, which show date and results of instruments calibrated or tested, must be included in the test report.

5. Calibrating standard shall be of higher accuracy than that of the instrument tested.

1.3 Division of Responsibility

A. The Contractor shall perform routine insulation-resistance, continuity, and rotation tests for all distribution and utilization equipment prior to and in addition to tests performed by the testing firm specified herein.

B. The Contractor shall supply electrical power to each test site. The testing firm shall specify the specific power requirements.

C. The Contractor shall notify the testing firm when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project scheduling.

D. The Contractor shall provide and submit for approval a short-circuit analysis and coordination study prior to completion of testing. The Contractor shall provide a complete set of electrical plans, specifications and change orders, as well as pertinent shop drawings, and manufacturer's instructions to the testing firm prior to commencement of testing. Coordination study shall include required set-points for coordinated devices.

E. The testing firm shall notify the Owner two weeks prior to commencement of any testing.

F. Any system, material, or workmanship which is found defective on the basis of acceptance tests shall be reported. The Owner will direct the Contractor to repair or replace the defective materials or equipment depending upon the effect.

G. The testing firm shall maintain a written record of all tests and shall assemble and certify a final test report.

1.4 Submittals

A. Submittals for approval.

1. Submit qualifications of testing firm for Engineer's approval.

2. Submit short circuit analysis and coordination study.

B. Submittals for project closeout.

1. Test Reports: The test reports shall include the following:

a. Summary of project.

b. Description of equipment tested.

c. Description of test and identification.

d. Test results.

e. Analysis and recommendations and remedial actions taken.

Part 2 Products

(NOT USED)

Part 3 Execution

3.1 Testing

A. The Contractor shall perform all tests required by individual Division 26 Sections.

B. Motor Tests: The independent testing firm shall perform and document the following inspections and tests on motors:

1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with approved Shop Drawings.

b. Inspect physical and mechanical condition.

c. Inspect for correct anchorage, mounting, grounding, connection, and lubrication.

d. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 10.12.

e. Verify the absence of unusual mechanical or electrical noise or signs of overheating during initial test run.

2. Electrical Tests - Induction Motors

a. Perform insulation-resistance tests in accordance with ANSI/IEEE Standard 43.

1) Motors larger than 200 Horsepower: Test duration shall be for 10 minutes. Calculate polarization index.

2) Motors 200 Horsepower and Less: Test duration shall be for 1 minute. Calculate the dielectric-absorption ratio.

3) Perform insulation-resistance test on pedestal in accordance with manufacturer's published data.

4) Verify that resistance temperature detector (RTD) circuits conform to Drawings. Verify that metering or relaying devices using the RTD's have the correct rating.

5) Verify that the motor space heater is functional where applicable.

6) Perform a rotation test to ensure correct shaft direction.

7) Measure running current and evaluate relative to load conditions and nameplate full-load amperes.

8) Perform vibration tests:

I. Motors larger than 200 Horsepower: Perform vibration baseline test. Plot amplitude versus frequency.

II. Motors 200 Horsepower and Less: Perform vibration amplitude test.

C. Thermographic Survey: The independent testing firm shall perform and document the baseline thermal operating conditions of all panels and electrical connections as described herein.

1. Visual and Mechanical Inspection

a. Inspect physical, electrical and mechanical condition.

b. Remove all necessary covers prior to thermographic inspection.

2. Provide report including the following:

a. Baseline conditions.

b. Discrepancies.

c. Temperature difference between the area of concern and the reference area.

d. Cause of temperature difference.

e. Areas inspected. Identify inaccessible and/or unobservable areas and/or equipment.

f. Identify load conditions at time of inspection.

g. Provide photographs and/or thermograms of the baseline conditions and of all deficiencies.

3. Test Parameters

a. Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 degree C at 30 degrees C.

b. Equipment shall detect emitted radiation and convert detected radiation to visual signal.

c. Thermographic surveys should be performed during periods of maximum possible loading but not less than 40 percent of rated load of the electrical equipment being inspected.

4. Test Results

a. Temperatures differences of 1 degree C to 3 degrees C indicate possible deficiency and shall be referred to the Engineer for direction to repair.

b. Temperature differences over 4 degrees C shall be repaired by the Contractor and retested by the testing firm.

END OF SECTION

Part 1 General

1.1 Summary

A. Section includes cables and related cable splices, terminations, and accessories for medium-voltage (2001 to 35,000 V) electrical distribution systems.

1.2 Definitions

A. Jacket: A continuous nonmetallic outer covering for conductors or cables.

B. NETA ATS: Acceptance Testing Specification.

C. Sheath: A continuous metallic covering for conductors or cables.

1.3 Action Submittals

A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

B. Sustainable Design Submittals:

1. Product Data: For each conductor and cable indicating lead content.
2. Product Data: For solvents and adhesives, indicating VOC content.
3. Laboratory Test Reports: For solvents and adhesives, indicating compliance with requirements for low-emitting materials.

1.4 Informational Submittals

A. Coordination Drawings: Indicate location of each cable, splice, and termination.

B. Qualification Data: For Installer.

C. Material Certificates: For each type of cable and accessory.

D. Design Data: Cable pulling calculations, including conduit size and fill percentage, pulling tensions, cable sidewall pressure, jam probability, voltage drop, and ground wire sizing for each cable.

E. Source quality-control reports.

F. Field quality-control reports.

1.5 Quality Assurance

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 Field Conditions

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify owner no fewer than fourteen days in advance of proposed interruption of electric service.

2. Do not proceed with interruption of electric service without owner's written permission.

Part 2 Products

2.1 System Description

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE C2 and NFPA 70.

C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.2 Cables

A. Basis-of-Design Product: Subject to compliance with requirements, provide product by General Cable; General Cable Corporation or comparable product by one of the following for example by:

1. Kerite Co. (The).

2. Okonite Company (The).

3. Southwire Company.

B. Cable Type: Type MV 105.

C. Conductor Insulation: Ethylene-propylene rubber.

1. Voltage Rating: 5/8 and 15 kV for respective systems.

2. Insulation Thickness: 133 percent insulation level.

D. Conductor: [1]Copper.

E. Comply with UL 1072, AEIC CS8, ICEA S-93-639/NEMA WC 74, and ICEA S-97-682.

F. Conductor Stranding: Compact round, concentric lay, Class B.

G. Strand Filling: Conductor interstices are filled with impermeable compound.

H. Lead Content: Less than 300 parts per million.

I. Shielding: Copper tape, helically applied over semiconducting insulation shield.

J. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.

K. Three-Conductor Cable Assembly: Three insulated, shielded conductors cabled together with ground conductors.

1. Circuit Identification: Color-coded tape (black, red, blue) under the metallic shielding.

L. Cable Sheath: Interlocked aluminum applied over cable.

M. Cable Jacket: Sunlight resistant PVC applied over armor.

2.3 Connectors

1. Basis-of-Design Product: Subject to compliance with requirements, provide product by Raychem; TE Connectivity or comparable product by one of the following for example by:

2. Cooper Power Systems, an Eaton business.

3. G&W Electric Company.

4. TE Connectivity Ltd.

5. Thomas & Betts Corporation; A Member of the ABB Group.

B. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.

C. Copper-Conductor Connectors: Copper barrel crimped connectors.

2.4 Solid Terminations

1. Basis-of-Design Product: Subject to compliance with requirements, provide product by Raychem; TE Connectivity or comparable product by one of the following for example by:

2. Cooper Power Systems, an Eaton business.

3. G&W Electric Company.

4. TE Connectivity Ltd.

5. Thomas & Betts Corporation; A Member of the ABB Group.

B. Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.

1. Compound-filled, cast-metal-body, metal-clad cable terminator for metal-clad cable with external plastic jacket.

2. Heat-shrink sheath seal kit with phase- and ground-conductor rejacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.

C. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone-rubber, insulator modules; shield ground strap; and compression-type connector.

2.5 Separable Insulated Connectors

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

1. Basis-of-Design Product: Subject to compliance with requirements, provide product by Raychem; TE Connectivity or comparable product for example by:

2. Cooper Power Systems, an Eaton business.

3. G&W Electric Company.

4. TE Connectivity Ltd.

5. Thomas & Betts Corporation; A Member of the ABB Group.

B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

C. Load-Break Cable Terminators: Elbow-type units with 200-A-load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

D. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.

2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.

3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.

4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

F. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

G. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 Splice Kits

A. Description: For connecting medium voltage cables; type as recommended by cable or splicing kit manufacturer for the application.

1. Basis-of-Design Product: Subject to compliance with requirements, provide product by Raychem; TE Connectivity or comparable product by one of the following for example by:

2. Cooper Power Systems, an Eaton business.

3. G&W Electric Company.

4. TE Connectivity Ltd.

5. Thomas & Betts Corporation; A Member of the ABB Group.

B. Standard: Comply with IEEE 404.

2.7 Medium-Voltage Tapes

A. Description: Electrical grade, insulating tape rated for medium voltage application.

B. Basis-of-Design Product: Subject to compliance with requirements, provide product by 3M or comparable product by one of the following for example by:

1. Cooper Power Systems, an Eaton business.

2. G&W Electric Company.

3. Raychem; TE Connectivity.

4. TE Connectivity Ltd.

5. Thomas & Betts Corporation; A Member of the ABB Group.

C. Ethylene/propylene rubber-based, 30-mil splicing tape, rated for 130 deg C operation. Minimum 3/4 inch wide.

D. Silicone rubber-based, 12-mil self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inches wide.

2.8 Arc-Proofing Materials

A. Description: Fire retardant, providing arc flash protection.

B. Basis-of-Design Product: Subject to compliance with requirements, provide product by 3M or comparable product by one of the following for example by:

1. Cooper Power Systems, an Eaton business.

2. G&W Electric Company.

3. Raychem; TE Connectivity.

4. TE Connectivity Ltd.

5. Thomas & Betts Corporation; A Member of the ABB Group.

C. Tape for First Course on Metal Objects: 10-mil- thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

D. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch thick, and compatible with cable jacket.

E. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1 inch wide.

2.9 Source Quality Control

A. Test and inspect cables according to ICEA S-97-682 before shipping.

B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig.

Part 3 Execution

3.1 Installation

A. Install cables according to IEEE 576.

B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inches on the pull rope.

1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.

2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.

C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.

2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.

4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

E. Support cables according to Section 26 05 29 "Hangers and Supports for Electrical Systems."

F. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.

G. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.

H. Pulls shall be continuous between equipment. Splices are not permitted on cables within raceways and only allowed in approved manholes.

I. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.

J. Install separable insulated-connector components as follows:

1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.

2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.

3. Standoff Insulator: At each terminal junction, with one on each terminal.

K. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage single conductor cables at locations not protected by conduit, switchgear compartmentalization, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.

2. Wrap metallic cable components with 10-mil pipe-wrapping tape.

3. Smooth surface contours with electrical insulation putty.

4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.

5. Band arc-proofing tape with two layers of 1-inch- wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.

L. Seal around cables passing through fire-rated elements in accordance with Section 26 05 00.

M. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

N. Identify cables according to Section 26 05 53 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 Field Quality Control

A. Testing Agency: Perform tests and inspections.

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS and as required in Section 26 05 01. Certify compliance with test parameters.

2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.

3. Perform direct-current High Potential test of each new conductor according to NETA ATS, Ch. 7.3.3. Do not exceed cable manufacturer's recommended maximum test voltage.

B. Medium-voltage cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Building wires and cables rated 2000 V and less.

2. Wires and cables for PV systems rated 2000 V and less.

3. Connectors, splices, and terminations rated 2000 V and less.

B. Related Requirements:

1. Section 26 05 23 - Control-Voltage Electrical Power Cables for control systems communications cables and Classes 1, 2, and 3 control cables.

1.2 Definitions

A. VFC: Variable-frequency controller.

1.3 Action Submittals

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.4 Informational Submittals

A. Field quality-control reports.

Part 2 Products

2.1 Conductors and Cables

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

1. Alpha Wire Company.

2. American Bare Conductor.

3. Belden Inc.

4. Cerro Wire L.L.C.

5. General Cable.

6. Lapp USA.

7. Service Wire Co.

8. Southwire Company.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable used in VFC circuits.

E. Conductors: Stranded copper, complying with NEMA WC 70/ICEA S-95-658.

1. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN/THWN-2 and Type XHHW-2 as required by the Execution paragraphs here-in.

2. Provide self-lubricated (low friction) version of thermoplastic or thermoset insulation.

F. Tray Cable

1. Description: ANSI/NFPA 70, Type TC, multi-conductor, suitable for use in tray, conduit, or duct.

2. Conductor: NEMA B stranded copper.

3. Insulation Voltage Rating: 600 volts.

4. Insulation Temperature Ratings: 75 degrees C.

5. Insulation Material: Type THWN for 10 AWG and larger; Type XHHW for 8 AWG and smaller.

6. Jacket Material: PVC.

7. Construction: Multi-conductor with 50% (3 minimum) integral ground conductors.

G. Metal Clad Cable

1. Description: ANSI/NFPA 70, Type MC, suitable for installation in cable tray, conduit, trench or wireway, indoors, outdoors, or underground.

2. Conductor: NEMA B stranded copper.

3. Configuration: 3 or 4 conductor with ground as indicated. Provide 50% (3 minimum) bare copper grounding conductors.

4. Insulation Voltage Rating: 600 volts.

5. Insulation Temperature Rating: 90 degrees C.

6. Insulation Material: Type XHHW.

7. Armor Material: Armor.

8. Armor Design: Interlocked aluminum armor.

9. Jacket: Black PVC.

H. VFC Cable:

1. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable.

2. Type TC-ER with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires, and sunlight- and oil-resistant outer PVC jacket.

2.2 Connectors and Splices

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

1. Hubbell Power Systems, Inc.

2. Ideal Industries, Inc.

3. Ilsco; a branch of Bardes Corporation.

4. NSi Industries LLC.

5. O-Z/Gedney; a brand of the EGS Electrical Group.

6. 3M; Electrical Markets Division.

7. Thomas & Betts.

B. Substitutions: In accordance with Section 01 25 00 - Substitution Procedures.

C. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

D. Wiring Connectors

1. Mechanical Connectors:

    a. For conductor sizes No. 8 AWG and larger, make all splices, taps and terminal connections using UL listed cast and machined high-conductivity copper alloy connectors of the circular clamp type with multiple socket-head cap screws manufactured by Thomas & Betts. Except where insulated covers are provided, fill voids and irregularities on connections with "Scotchfil" insulation putty and cover neatly with 2 half-lapped layers of Scotch No. 88 insulating tape and one half-lapped layer of friction tape.

2. Spring Wire Connectors:

    a. 3-M Company, Model "Scotch-lok" or "Hyflex".

    b. Ideal Industries, Model "Wingnut".

3. Strap-Screw Terminal Connectors: Use ring-tongue or locking fork lugs on all strap-screw device terminals; do not exceed 3 lugs per terminal. Use crimping tools which are specifically designed for the application.

4. Armored Cable Connectors:

    a. O-Z, Model "PG" Armor terminator.

Part 3 Execution

3.1 Conductor Material Applications

A. Feeders: NEMA Class B stranded copper.

B. Branch Circuits: Copper; stranded.

C. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

3.2 Conductor Insulation and Multiconductor Cable Applications and Wiring Methods

A. Service Entrance: Type XHHW-2, single conductors in raceway unless otherwise indicated.

B. Feeders (Larger than No. 4 AWG): Type XHHW-2, single conductors in raceway, 90°C; wet location rated 75°C.

C. Feeders (4 AWG and Smaller): Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

E. Feeders in Cable Tray: Metal-clad cable, Type MC.

F. Branch Circuits: Type THHN/THWN-2, single conductors in raceway.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

H. Branch Circuits in Cable Tray: Metal-clad cable, Type MC.

I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

J. VFC Output Circuits: Type TC-ER cable with braided shield.

K. DC Circuits: Type W or locomotive cable. Extremely flexible, outdoor and cable tray rated in raceway.

3.3 Installation of Conductors and Cables

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 26 05 33 - Raceways and Boxes for Electrical Systems prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

F. Support cables according to Section 26 05 29 - Hangers and Supports for Electrical Systems.

G. Pull all conductors into raceway at same time.

H. Protect exposed cable from damage.

I. Use suitable cable fittings and connectors.

J. Neatly train and lace wiring inside boxes, equipment, and panelboards. Lace wiring in cable tray at no more than 10-foot intervals using T&B "Ty-Raps" of appropriate size and type.

K. Clean conductor surfaces before installing lugs and connectors.

L. Use mechanical connectors for copper conductor splices and taps, 6 AWG and larger. Tape uninsulated conductors and connector with electrical tape to 150 percent of insulation rating of conductor. Taps shall only be permitted where specifically indicated on the Drawings.

M. Use insulated spring wire connectors with plastic caps for copper conductor splices, 10 AWG and smaller.

N. Leave slack in wire and cable at all termination and junction points.

O. Do not splice feeders unless specifically approved by the Owner's Representative and Engineer. When approved make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.

P. Use irreversible compression connectors for copper conductor splices and taps, 6 AWG and larger. Tape uninsulated conductors and connector with electrical tape to 150 percent of insulation rating of conductor. Cover connection with cold shrink rubber sleeve.

3.4 Connections

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack. Terminate stranded conductors with compression locking fork terminals, and then secure the terminal under the side screw.

3.5 Identification

A. Identify and color-code conductors and cables according to Section 26 05 53 - Identification for Electrical Systems. For cables smaller than No. 4 AWG use colored insulation. For cables No. 4 AWG and larger, black insulation with colored marking tape may be used.

B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.6 Sleeve and Sleeve-Seal Installation For Electrical Penetrations

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 44 - Sleeves and Sleeve Seals for Electrical Raceways and Cabling.

3.7 Firestopping

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 26 05 00 - Basic Electrical Materials and Methods. Bond sleeves to ground with code sized bonding jumper.

3.8 Field Quality Control

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections of all feeders and any branch circuits 100A and greater. Refer to Section 26 05 01 - Electrical Testing for additional requirements.

B. Perform the following tests and inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors and conductors on circuits 100A and greater for compliance with requirements.

2. Perform each of the following visual and electrical tests in accordance with NETA ATS and Section 26 05 01 - Electrical Testing:

   a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.

   b. Test bolted connections for high resistance using one of the following:

      1) Calibrated torque wrench.

   c. Inspect compression applied connectors for correct cable match and indentation.

   d. Inspect for correct identification.

   e. Inspect cable jacket and condition.

   f. Insulation-resistance test on each conductor with respect to ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.

   g. Continuity test on each conductor and cable.

   h. Uniform resistance of parallel conductors.

3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each connection in conductors No. 4 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

4. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

C. Cables will be considered defective if they do not pass tests and inspections and shall be replaced completely.

D. Prepare test and inspection reports to record the following:

1. Procedures used.

2. Results that comply with requirements.

3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Multimode optical-fiber cabling.
2. UTP cabling.
3. RS-485 cabling.
4. Low-voltage control cabling.
5. Control-circuit conductors.
6. Identification products.

1.2 Definitions

A. EMI: Electromagnetic interference.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

C. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

D. RCDD: Registered Communications Distribution Designer.

E. UTP: Unshielded twisted pair.

1.3 Action Submittals

A. Product Data: For each type of product.

1.4 Informational Submittals

A. Field quality-control reports.

1.5 Quality Assurance

A. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

Part 2 Products

2.1 System Description

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 Performance Requirements

A. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262 by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

1. Flame Travel Distance: 60 inches or less.

2. Peak Optical Smoke Density: 0.5 or less.

3. Average Optical Smoke Density: 0.15 or less.

B. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

C. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.3 Backboards

A. Provide the following:

1. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches.

2. Painting: Paint plywood on all sides and edges with eggshell, white, alkyd paint.

2.4 Optical-Fiber Cable

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. AMP NETCONNECT; a Tyco Electronics brand; a TE Connectivity Ltd. company.

2. Belden Inc.

3. Berk-Tek; a Nexans company.

4. CommScope, Inc.

5. Corning Cable Systems.

6. General Cable; General Cable Corporation.

7. Siemon Co. (The).

8. Tyco Electronics Corporation; a TE Connectivity Ltd. company.

B. Description: Single mode, 50/125-micrometer, 12-fiber, nonconductive, tight-buffer, optical-fiber cable unless otherwise indicated.

1. Comply with ICEA S-83-596 for mechanical properties.

2. Comply with TIA-568-B.3 for performance specifications.

3. Comply with TIA-492AAAA-A for detailed specifications.

4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

a. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.

b. Riser Rated, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

c. General Purpose, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.

5. Maximum Attenuation: 3.5 dB/km at 850 nm; 1.5 dB/km at 1300 nm.

6. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

7. Conductive Cable shall be aluminum armored type.

C. Jacket:

1. Jacket Color: Aqua for 50/125-micrometer cable.

2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-B.

3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.5 Optical-Fiber Cable Hardware

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Berk-Tek; a Nexans company.
3. Corning Cable Systems.
4. Dynacom Corporation.
5. Hubbell Premise Wiring.
6. Optical Connectivity Solutions Division.
7. Panduit Corp.
8. Siemon Co. (The).

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths.

D. Cable Connecting Hardware:

1. Comply with Optical-Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2, TIA-604-3-A, and TIA/EIA-604-12. Comply with TIA-568-B.3.
2. Quick-connect, Type LC connectors. Insertion loss of not more than 0.75 dB.

2.6 UTP Cable

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

1. Alpha Wire Company; a division of Belden Inc.
2. Belden Inc.
3. CommScope, Inc.
4. Draka Cableteq USA.
5. Genesis Cable Products; Honeywell International, Inc.

6. Mohawk; a division of Belden Inc.

7. Siemon Company (The).

8. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: 100-ohm, four-pair UTP and 24-pair UTP, formed into four-pair binder groups with no overall jacket.

1. Comply with ICEA S-102-700 for mechanical properties of Category 6 cables.

2. Comply with TIA-568-C.1 for performance specifications.

3. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

a. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

b. Communications, Riser Rated: Type CMP or Type CMR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

c. Communications, General Purpose: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

2.7 UTP Cable Hardware

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

2. American Technology Systems Industries, Inc.

3. AMP NETCONNECT; a Tyco Electronics brand; a TE Connectivity Ltd. company.

4. Dynacom Corporation.

5. Hubbell Premise Wiring.

6. Leviton Manufacturing Co., Inc.

7. Panduit Corp.

8. Siemon Co. (The).

9. Siecor.

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: 110-style IDC for Category 5e. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

1. Number of Terminals per Field: One for each conductor in assigned cables.

D. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Number of Jacks per Field: One for each four-pair conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria.

E. Jacks and Jack Assemblies: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-C.1.

F. Patch Cords: Factory-made, four-pair cables in 36-inch lengths; terminated with eight-position modular plug at each end.

1. Patch cords shall have color-coded boots for circuit identification.

G. Workstation Outlets: Four-port-connector assemblies mounted in single faceplate. Outdoors and in areas subject to open water and damp locations; use wet location covered outlets as indicated.

H. Faceplates:

1. Metal Faceplate: Stainless steel, complying with requirements in Section 26 27 26 - Wiring Devices.

2. For use with snap-in jacks accommodating any combination of UTP, optical-fiber, and coaxial work area cords.

a. Flush-mounted jacks, positioning the cord at a 45-degree angle.

I. Legend:

1. Machine printed, in the field, using adhesive-tape label.

2.8 Twin-Axial Data Highway Cable

A. Standard Cable: NFPA 70, Type CM.

1. Paired, pairs as noted on drawings, No. 20 AWG, stranded (7x28) tinned-copper conductors.
2. Polypropylene insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. PVC jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with UL 1685.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, pairs as noted on drawings, No. 20 AWG, stranded (7x28) tinned--copper conductors.
2. Plastic insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. Plastic jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

2.9 RS-485 Cable

A. Standard Cable: NFPA 70, Type CMG.

1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262.

2.10 Low-Voltage Control Cable

A. Paired Cable: NFPA 70, Type CMG.

1. One-pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One-pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.11 Control-Circuit Conductors

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

1. Encore Wire Corporation.
2. General Cable; General Cable Corporation.
3. Southwire Company.
4. Lapp.

5. Belden.

6. Alpha Wire.

7. Anixter.

B. Class 1 Control Circuits: Stranded copper, Type RHW-2, in raceway, complying with UL 44. No 14 AWG unless otherwise indicated.

C. Class 2 Control Circuits: Stranded copper, tray cable (TC), in cable tray or raceway, complying with UL 44.

D. Class 3 Remote-Control and Signal Circuits: Stranded copper, power-limited tray cable (PLTC), in cable tray or raceway, complying with UL 83.

E. Multi-conductor control cables shall have an overall XLPE jacket and XL-CPE insulation on stranded copper conductors. Conductor insulation shall be numbered “1 to N” and colored per ICEA S-73-532 Table E-2. Cables shall be listed for 90% operation wet or dry. Cables shall be listed for cable tray applications (TC) meeting VW-1.

2.12 Source Quality Control

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP cables according to TIA-568-C.2.

C. Factory test optical-fiber cables according to TIA-568-C.3.

D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

Part 3 Execution

3.1 Examination

A. Test cables on receipt at Project site.

1. Test optical-fiber cable to determine the continuity of the strand end to end. Use optical loss test set.

2. Test optical-fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.

3. Test each pair of UTP cable for open and short circuits.

3.2 Installation of Raceways and Boxes

A. Comply with requirements in Section 26 05 33 - Raceways and Boxes for Electrical Systems for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.

1. Outlet boxes shall be no smaller than 4 inches square by 2-1/8 inches deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.

2. Flexible metal conduit shall not be used.

B. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.

C. Install manufactured conduit sweeps and long-radius elbows if possible.

D. Raceway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.

2. Install cable trays to route cables if conduits cannot be located in these positions.

3. Secure conduits to backboard if entering the room from overhead.

4. Extend conduits 6 inches above finished floor unless otherwise indicated.

5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

E. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.3 Installation of Conductors and Cables

A. Comply with NECA 1 and NFPA 70.

B. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.

2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems."

3. Terminate all conductors and optical fibers; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.

4. Cables may not be spliced.

5. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Install lacing bars and distribution spools.

7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

8. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Do not use heat lamps for heating.

9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Monitor cable pull tensions.

10. Support: Do not allow cables to lay on removable ceiling tiles.

11. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.

C. UTP Cable Installation:

1. Comply with TIA-568-C.2.

2. Do not untwist UTP cables more than 1/2 inch at the point of termination to maintain cable geometry.

D. Installation of Control-Circuit Conductors:

1. Install wiring in raceways. Comply with requirements specified in Section 26 05 33 - Raceways and Boxes for Electrical Systems.

E. Optical-Fiber Cable Installation:

1. Comply with TIA-568-C.3.

2. Terminate cable on connecting hardware that is rack or cabinet mounted.

F. Open-Cable Installation: NOT PERMITTED

G. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.

2. Install cabling after the flooring system has been installed in raised floor areas.

3. Below each feed point, neatly coil a minimum of 10 feet of cable in a coil not less than 12 inches in diameter.

H. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.

2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 5 inches.

b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 12 inches.

c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 2-1/2 inches.

b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 6 inches.

c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.

b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 3 inches.

c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches.

6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 Removal of Conductors and Cables

A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified for future use with a tag.

3.5 Control-Circuit Conductors

A. Minimum Conductor Sizes unless otherwise indicated on Drawing or directed by equipment manufacturers:

1. Class 1 remote-control and signal circuits; No 14 AWG.

2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.

3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 16 AWG.

3.6 Firestopping

A. Comply with requirements in Section 26 05 00 - Basic Electrical Materials, for penetration firestopping.

B. Comply with TIA-569-B, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.7 Grounding

A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For low-voltage control wiring and cabling, comply with requirements in Section 26 05 26 - Grounding and Bonding for Electrical Systems.

3.8 Identification

A. Comply with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.

B. Identify data and communications system components, wiring, and cabling according to TIA-606-A; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

3.9 Field Quality Control

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

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections:

1. Visually inspect UTP and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments and inspect cabling connections to confirm compliance with TIA-568-C.1.

2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

3. Test UTP cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross-connection.

   a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

4. Optical-Fiber Cable Tests:

   a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

   b. Link End-to-End Attenuation Tests:

      1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.

      2) Attenuation test results for links shall be less than 2.0 dB according to equation in TIA-568-C.0.

D. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION

Part 1 General

1.1 Summary

A. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.2 Action Submittals

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

1.3 Informational Submittals

A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.

B. Field quality-control reports.

1.4 Quality Assurance

A. Testing Agency Qualifications: Refer to Section 26 05 01 - Electrical Testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 467 for grounding and bonding materials and equipment.

Part 2 Products

2.1 Manufacturers

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

1. Burndy; Part of Hubbell Electrical Systems.

2. ERICO International Corporation.

3. Fushi Copperweld Inc.

4. Harger Lightning & Grounding.

5. ILSCO.

6. O-Z/Gedney; a brand of Emerson Industrial Automation.

7. Robbins Lightning, Inc.

2.2 System Description

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 Conductors

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Stranded Conductors: ASTM B 8.

2. Tinned Conductors: ASTM B 33.

3. Bonding Conductor: No. 4 AWG, stranded conductor.

4. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart unless otherwise indicated. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 Connectors

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

E. Irreversible Compression Connectors: Burndy Hy-Ground or equivalent by T&B.

2.5 Grounding Electrodes

A. Ground Rods: Copper-clad steel, sectional type; 3/4 inch by 10 feet unless otherwise indicated.

Part 3 Execution

3.1 Applications

A. Conductors: Install stranded copper conductors unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 4/0 AWG minimum.

1. Bury at least 24 inches below grade.

2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

2. Underground Connections: Welded connectors or irreversible compression connector except at test wells and as otherwise indicated.

3. Connections to Ground Rods at Test Wells: Bolted connectors.

4. Connections to Structural Steel: Welded connectors.

5. Connections to Rebar: Listed compression clamp.

6. Bonding connector where steel raceway is not effectively bonded: OZ-Gedney #GH-B or equivalent.

3.2 Grounding at the Service

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 Grounding Separately Derived Systems

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 Grounding Underground Distribution System Components

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches (unless utility company has more stringent requirements): Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.5 Equipment Grounding

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.6 Installation

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.

2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 26 05 43 - Underground Ducts and Raceways for Electrical Systems, and shall be at least 12 inches deep, with cover. Provide “Ground” legend on cover of test well.

1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.

2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart, unless otherwise indicated.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column and indicated item, extending around the perimeter of building or area or item indicated.

1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.

2. Bury ground ring not less than 36 inches from building's foundation and not less than 24 inches below rough grade.

J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4/0 AWG.

1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.

2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

K. Make grounding connections to building steel by exothermic weld unless specifically indicated otherwise and approved.

L. Cable trays shall be grounded with a #4/0 bare stranded copper grounding conductor bonded to each section.

M. As far as practical, grounding cable shall be continuous, without joints or splices throughout its length.

N. Bolted grounding connections shall use corrosion-resistant materials.

O. Exposed ground cable shall be protected against mechanical injury. Ground cable passing through concrete floor slabs or through walls shall be protected by schedule 80 rigid PVC, rigid conduit sleeves projecting 6 inches above and below floor slab.

P. All electrical equipment shall be grounded by direct connection to the copper grounding network. Conduits or building structural steel are unacceptable as adequate paths to ground.

Q. Conduits shall be grounded to the metal framework of the switchgear motor control centers, boxes and equipment where they terminate. Conduits running from cable trays shall be bonded to the trays. Conduits terminating at locations other than equipment shall also be connected to ground.

3.7 Field Quality Control

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections in accordance with Section 26 05 01 - Electrical Testing.

B. Perform tests and inspections.

C. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, or at individual ground rods where test wells are not specified. Make tests at ground rods before any conductors are connected.

a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare Record Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

D. Grounding system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.

2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.

3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.

4. Substations and Pad-Mounted Equipment: 5 ohms.

5. Manhole Grounds: 10 ohms.

G. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.

2. Construction requirements for concrete bases.

1.2 Action Submittals

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

   a. Hangers.

   b. Steel slotted support systems.

   c. Trapeze hangers.

   d. Clamps.

2. Include rated capacities and furnished specialties and accessories.

1.3 Informational Submittals

A. Welding certificates.

1.4 Quality Assurance

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

Part 2 Products

2.1 Performance Requirements

A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.

2. Self-extinguishing according to ASTM D 635.

2.2 Support, Anchorage, and Attachment Components

A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.

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

    a. Allied Tube & Conduit.

    b. Cooper B-Line, Inc.; a division of Cooper Industries.

    c. ERICO International Corporation.

    d. GS Metals Corp.

    e. Haydon Corporation.

    f. Thomas & Betts Corporation; a member of the ABB Group.

    g. Unistrut; an Atkore International company.

2. Material: Stainless steel.

3. Channel Width: 1-5/8 inches.

4. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.

5. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

6. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Stainless-steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

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

      1) Hilti, Inc.

      2) ITW Ramset/Red Head; Illinois Tool Works, Inc.

      3) MKT Fastening, LLC.

      4) Simpson Strong-Tie Co., Inc.

2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

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

      1) Cooper B-Line, Inc.; a division of Cooper Industries.

      2) Empire Tool and Manufacturing Co., Inc.

      3) Hilti, Inc.

      4) ITW Ramset/Red Head; Illinois Tool Works, Inc.

      5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.

4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.

5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

6. Toggle Bolts: 316 Stainless-steel springhead type.

7. Hanger Rods: Threaded 316 stainless steel in plant and pump station process areas and galvanized steel in non-process spaces.

2.3 Fabricated Metal Equipment Support Assemblies

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Sections for steel shapes and plates.

Part 3 Execution

3.1 Application

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.

B. Comply with requirements for raceways and boxes specified in Section 26 05 33 - Raceways and Boxes for Electrical Systems.

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in Table at the end of this Section, where Table lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 3/8 inch in diameter.

D. Multiple Raceways: Install trapeze-type supports fabricated with stainless steel slotted support system in process areas or galvanized steel in non-process areas, sized so capacity can be increased by at least 50 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 Support Installation

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

1. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 pounds, provide additional strength until there is a minimum of 200 pounds safety allowance in the strength of each support.

2. Install individual and multiple raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.

3. Support parallel runs of horizontal raceways together on trapeze-type hangers.

4. Support individual horizontal raceways by separate pipe hangers.

5. Space supports for raceways in accordance with Table 1 of this Section. Space supports for raceway types not covered by the above in accordance with NEC.

6. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported, and raceway terminals are not made with chase nipples or threadless box connectors.

7. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.

B. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.

2. To New Concrete: Bolt to concrete inserts.

3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.

4. To Existing Concrete: Expansion anchor fasteners.

5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.

6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts or beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.

7. To Light Steel: Sheet metal screws.

8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

C. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 Installation of Fabricated Metal Supports

A. Comply with installation requirements in Division 05 Sections for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 Concrete Bases

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03.

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

2. Install anchor bolts to elevations required for proper attachment to supported equipment.

3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 Painting

A. Touchup: Clean field welds and abraded areas of paint. Paint exposed areas immediately after erecting hangers and supports. Comply with SSPC-PA 1 requirements for touching up painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

SPACING FOR RACEWAY SUPPORTS

Raceway Size	Location	Spacing (Feet)			
			RMC/IMC	EMT	RNC
1/2", 3/4", 1"	Horizontal		8	5	3
1/2", 3/4", 1", 1-1/4", 1-1/2", 2"	Vertical		10	8	5
1-1/4", 1-1/2", 2"	Horizontal		10	8	5
3", 4"	Horizontal		15	10	10
3", 4"	Vertical		20	10	10
Cable Tray	Horizontal	10'			
Cable Tray	Vertical	20"			

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 26 05 43 "Underground Ducts and Raceways for Electrical Systems" for exterior duct banks, manholes, and underground utility construction.

1.2 Definitions

A. GRC: Galvanized rigid steel conduit.

B. IMC: Intermediate metal conduit.

1.3 Action Submittals

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.4 Informational Submittals

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. Process, HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

3. Verify that field measurements are as shown on Drawings. Confirm with final equipment shop drawings.

4. Verify routing and termination locations of conduit prior to rough-in.

5. Conduit routing is shown on Drawings in approximate locations unless dimensioned. Route as required to complete wiring system.

B. Seismic Qualification Certificates (where required): For enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

C. Source quality-control reports.

Part 2 Products

2.1 Metal Conduits, Tubing, And Fittings

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

1. AFC Cable Systems, Inc.

2. Allied Tube & Conduit; a part of Atkore International.

3. Anamet Electrical, Inc.

4. Electri-Flex Company.

5. O-Z/Gedney; a brand of Emerson Industrial Automation.

6. Republic Conduit.

7. Robroy Industries.

8. Thomas & Betts Corporation, A Member of the ABB Group.

9. Western Tube and Conduit Corporation.

10. Wheatland Tube Company.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. NO PVC-Coated Steel Conduit or NO PVC-coated rigid steel conduit will be allowed for this project.

E. EMT: Comply with ANSI C80.3 and UL 797.

F. FMC: Comply with UL 1; zinc-coated steel.

G. LFMC: Flexible steel conduit allowed without PVC jacket and complying with UL 360.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B; material to match conduit.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.

2. Fittings for EMT:

   a. Material: Die cast.

   b. Type: Compression.

3. Expansion Fittings: Steel, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

4. Steel Fittings (Provide similar series fittings for other materials): For rigid steel conduit provide zinc coated, cast malleable, ferrous metal, threaded fittings, Appleton "form 35 Unilets" or Crouse-Hinds "Form 7 Condulets". Provide a neoprene cover gasket on each fitting installed outdoors.

5. "Mogul Fittings": Provide "Mogul" size fittings for conduit larger than 2 inches.

6. Grounding Bushings: Provide Appleton Type "GIB" Crouse-Hinds Type "GB" or Thomas & Betts 3800 Series threaded, grounding type insulated, metallic bushing, in combination with one exterior and one interior locknut, on each rigid conduit terminating in sheet metal box, cabinet, trough, gutter or wireway.

7. Sealing Bushings: Provide O.Z. compound bushing or sealing bushing on each conduit entering the building from outside underground and on each conduit passing from one space into another which is normally at a lower temperature.

8. Hubs: Provide Appleton "HUB" or "HUB-U" Series or Thomas & Betts "370" Series hub on each conduit terminating in a box or cabinet exposed to the weather.

9. Unions: Where conduit unions are necessary, provide Appleton Type "EC" or Thomas & Betts "Erickson coupling".

10. Fire Barriers: Provide barriers in all openings and around all penetrations in fire-rated walls and floors. Seal with fireproof sealant in accordance with Section 26 05 00 “Basic Electrical Materials and Methods and Division 07 as applicable.

I. Joint Compound for GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 Nonmetallic Conduits And Fittings

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

1. CANTEX INC.
2. CertainTeed Corporation.
3. Condux International, Inc.
4. Kraloy.
5. Lamson & Sessions.
6. RACO; Hubbell.
7. Thomas & Betts Corporation, A Member of the ABB Group.

B. Listing and Labeling: Nonmetallic conduits and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

D. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

E. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 Metal Wireways And Auxiliary Gutters

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

1. Cooper B-Line, Inc.; a division of Cooper Industries.

2. Hoffman; a brand of Pentair Equipment Protection.

3. MonoSystems, Inc.

4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 12 for indoor applications and Type 4X for all exterior and interior areas subject to moisture and corrosion unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Flanged-and-gasketed type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 Surface Raceways

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.

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

   a. Hubbell Incorporated.

   b. MonoSystems, Inc.

   c. Wiremold / Legrand.

C. Surface Nonmetallic Raceways (PVC only allowed in underground concrete-encased duct banks): Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated.
   b. MonoSystems, Inc.
   c. Panduit Corp.
   d. Wiremold / Legrand.

D. Tele-Power Poles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated.
   b. MonoSystems, Inc.
   c. Panduit Corp.
   d. Wiremold / Legrand.
2. Material: Aluminum with clear anodized finish.
3. Fittings and Accessories: Dividers, end caps, covers, cutouts, wiring harnesses, devices, mounting materials, and other fittings shall match and mate with tele-power pole as required for complete system.

2.5 Boxes, Enclosures, And Cabinets

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

1. Adalet.
2. Cooper Technologies Company; Cooper Crouse-Hinds.
3. EGS/Appleton Electric.
4. Erickson Electrical Equipment Company.
5. Hoffman.
6. Hubbell Incorporated.

7. Kraloy.

8. O-Z/Gedney.

9. RACO; Hubbell.

10. Robroy Industries.

11. Stahlin Non-Metallic Enclosures.

12. Thomas & Betts Corporation.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Metal Floor Boxes:

1. Material: Cast metal.

2. Type: Semi-adjustable.

3. Shape: Rectangular.

4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Nonmetallic Floor Boxes (All boxes to be stainless steel unless otherwise specified or approved by customer): Nonadjustable, rectangular.

1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application. Provide brass trim cover.

G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

J. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

K. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

L. Gangable boxes are prohibited.

M. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 4X in all exterior non-hazardous locations and in interior wet and corrosive, but non-hazardous locations; Type 12 in interior locations with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

2. Nonmetallic Enclosures: Fiberglass.

3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

N. Cabinets and Enclosures:

1. NEMA 250, Type as indicated on drawings. Where not specifically noted on the drawings, apply the following table:

a. NEMA 250; Type 1. Use only in atmospherically controlled clean areas such as offices.

b. NEMA 250; Type 12. Use in non-hazardous plant areas unless otherwise indicated. Use in equipment rooms.

c. NEMA 250; Type 4. Use for outdoor applications.

d. NEMA 250; Type 4X. Use for chemical handling and processing areas. Use where corrosive, non-hazardous atmospheres exist.

e. NEMA 250; Type 6P. Use for areas that may encounter temporary submergence.

f. NEMA 250; Type 7. Use for Class I hazardous locations.

2. Hinged door in front cover with flush latch and concealed hinge.

3. Key latch to match panelboards.

4. Metal barriers to separate wiring of different systems and voltage.

5. Accessory feet where required for freestanding equipment.

6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 Handholes And Boxes For Exterior Underground Wiring

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.

2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

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

a. Armorcast Products Company.

b. Oldcastle Precast, Inc.

c. Quazite: Hubbell Power Systems, Inc.

d. Synertech Moulded Products.

2. Standard: Comply with SCTE 77.

3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.

4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.

5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

6. Cover Legend: Molded lettering, legend as indicated.

7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

8. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.7 Source Quality Control For Underground Enclosures

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.

2. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

Part 3 Execution

3.1 Raceway Application

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Underground Installations:

   a. More than 5 Feet from Foundation Wall: Use thickwall nonmetallic conduit.

   b. Within 5 Feet from Foundation Wall: Use [1]stainless steel rigid.

   c. In or Under Slab on Grade: Use [1]stainless steel rigid conduit elbows for risers and thickwall nonmetallic conduit for horizontal runs.

   d. Minimum Size: 1 inch unless otherwise noted.

2. Outdoor Locations, Above Grade:

   a. Non-Corrosive Environments: Use [1]stainless steel rigid conduit unless otherwise indicated.

   b. Corrosive Environments (e.g. areas when waste water or chemicals may be present): Use [1]stainless steel rigid conduit and fittings unless otherwise indicated. NO PVC coated rigid galvanized steel conduit and fittings will be allowed for this project.

3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC except in hazardous locations, listed and approved outdoor explosion-proof flexible conduit shall be used.

4. Minimum Size: 3/4 inch unless otherwise indicated.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. In Slabs Above Grade:

   a. Use rigid steel conduit.

   b. Maximum Size Conduit in Slab: 3/4 inch.

2. Wet and Damp Locations (no other corrosives): Use rigid galvanized steel conduit.

3. Dry Locations Not Treatment, Non-Chemical Areas:

    a. Concealed: Use rigid steel conduit for feeders 2 inches and above: electrical metallic tubing for branch circuits and systems.

    b. Exposed: Use rigid steel conduit.

4. In Wetwells and Tanks and Processing Areas: Use rigid galvanized steel conduit. NO PVC coated rigid galvanized steel conduit allowed.

5. In Chemical Rooms: Use rigid galvanized steel conduit. NO PVC conduit allowed unless concealed in underground concrete duct bank.

6. In Contact with Concrete: Use rigid galvanized steel elbows and risers. NO PVC coated rigid galvanized steel allowed.

7. Connection to Vibrating Equipment: Including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment: liquid tight flexible metal conduit except hazardous locations shall use listed explosion-proof flexible fittings.

C. Minimum Raceway Size: 3/4-inch trade size except where otherwise indicated. Where connecting to equipment or instruments with hubs smaller than 3/4-inch, the LFMC final connection shall be reduced to match the equipment.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.

2. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.

3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth. No aluminum RGS is allowed for this project.

F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 Installation

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies.

B. Keep raceways at least 12 inches away from parallel runs of flues and steam or hot-water pipes and surfaces exceeding 104°F. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for hangers and supports and arrange to prevent misalignment.

E. Support conduit using lay-in adjustable hangers, clevis hangers, and split hangers, material to match conduit.

F. Group related conduits; support using conduit rack. Construct rack using channel and supports as specified under Section 26 05 29 “Hangers and Supports for Electrical Systems”; provide space on each for 50 percent additional conduits.

G. Do not support conduit with wire or perforated pipe straps. Remove wire used for temporary supports.

H. Do not attach conduit to ceiling support wires.

I. Arrange stub-ups so curved portions of bends are not visible above finished slab and protect from damage. Stub-ups shall be 6 inches above the floor unless equipment installation instructions limit to less.

J. Conceal conduit and EMT within finished walls, ceilings, and floors where indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches of enclosures to which attached.

L. Raceways Embedded in Slabs:

1. Run conduit parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.

2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.

3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.

4. Do not embed threadless fittings in concrete.

M. Stub-ups to Above Recessed Ceilings:

1. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

O. Run exposed, parallel, or banked raceways together. Make bends in parallel or banked runs from the same center line so that the bends are parallel. Factory elbows may be used in banked runs only where they can be installed parallel. This requires that there be a change in the plane of the run such as from wall to ceiling and that the raceways be of the same size. In other cases provide field bends for parallel raceways. Install exposed raceways parallel and perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical.

P. Arrange conduit to maintain headroom and present neat appearance. Where possible, install horizontal raceway runs above water and process piping. Maintain adequate clearance between conduit and piping.

Q. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

R. Make bends and offsets so the inside diameter is not effectively reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.

S. Cut conduit square using saw or pipe cutter; de-burr cut ends.

T. Bring conduit to shoulder of fittings; fasten securely.

U. PVC conduit is only allowed in underground concrete-encased duct banks. Join nonmetallic conduit using cement as recommended by manufacturer. Wipe nonmetallic conduit dry and clean before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for 20 minutes, minimum.

V. Join raceways with fittings designed and approved for the purpose and make joints tight. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Make raceway terminations tight. Where terminations are subject to vibration; use bonding bushings or wedges to ensure electrical continuity. Where subject to vibration or dampness, use insulating bushings to protect conductors.

W. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts and dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside the box.

X. Use conduit hubs to fasten conduit to sheet metal boxes in plant, damp and wet locations to cast boxes.

Y. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.

Z. Install no more than equivalent of three 90 degree bends between boxes. Use conduit bodies to make sharp changes in direction, as around beams. Use hydraulic one-shot bender to fabricate bends in metal conduit larger than 2 inch size. Low voltage and Signal System Raceways 2-Inch Trade Size and Smaller: In addition to the above requirements, install raceways 2-inch and smaller trade size in maximum lengths at 150 feet and with a maximum of two, 90 degree bends or equivalent. Install pull or junction boxes where necessary to comply with these requirements.

AA. Avoid moisture traps; provide junction box with drain fitting at low points in conduit systems.

BB. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

CC. Surface Raceways:

1. Install surface raceway with a minimum 2-inch radius control at bend points.

2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

DD. Provide seal-off fittings in raceways between areas of hazardous classification and unclassified areas.

EE. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

FF. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.

2. Where an underground service raceway enters a building or structure.

3. Where otherwise required by NFPA 70.

GG. Expansion-Joint Fittings:

1. Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.

2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

   a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.

   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.

   c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.

3. Install expansion fittings at all locations where conduits cross building or structure expansion joints.

4. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

HH. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for instruments, transformers and motors.

II. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

JJ. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

KK. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

LL. Locate boxes so that cover or plate will not span different building finishes.

MM. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

NN. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

OO. Set metal floor boxes level and flush with finished floor surface.

PP. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 Sleeve And Sleeve-Seal Installation For Electrical Penetrations

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies as specified in Section 26 05 44.

3.4 Firestopping

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 26 05 44.

3.5 Protection

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

2. Repair damage to paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Ladder cable tray.
2. Wire-mesh cable tray.
3. Cable tray accessories.
4. Warning signs.

1.2 Action Submittals

A. Product Data: For each type of product.

1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.

C. Delegated-Design Submittal: For seismic restraints.

1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer who is licensed in the state where Project is located and who is responsible for their preparation.
2. Design Calculations: Calculate requirements for selecting seismic restraints.
3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

1.3 Informational Submittals

A. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

B. Seismic Qualification Certificates (only if applicable): For cable trays, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

Part 2 Products

2.1 Performance Requirements

A. Delegated Design: Engage a qualified professional engineer to design cable tray supports and seismic bracing (only if required).

B. Seismic Performance (only if required): Cable trays and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "cable trays will remain in place without separation of any parts when subjected to the seismic forces specified."

2. Component Importance Factor: 1.5 for communications trays and 1.0 for others.

3. Refer to Structural Drawings.

C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.

1. Temperature Change: 80 deg F, ambient; 180 deg F, material surfaces.

2.2 General Requirements For Cable Tray

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles on individual cable tray types for specific values for the following parameters:

1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.

2. Concentrated Load: A load applied at midpoint of span and centerline of tray.

3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.3 Ladder Cable Tray

A. Manufacturers: Subject to compliance with requirements, provide products for example by:

1. B-line, an Eaton business.
2. Chalfant Manufacturing Company.
3. Cope Cable Tray; A Part of Atkore International.
4. MP Husky USA Cable Tray & Cable Bus.
5. Thomas & Betts Corporation; A Member of the ABB Group.
6. GS Metals; Globetray.

B. Description:

1. Configuration: Two longitudinal side rails outside flange with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
2. Width: As indicated on Drawings.
3. Minimum Usable Load Depth: 4 inches and 6 inches as indicated.
4. Straight Section Lengths: Up to 24 feet, except where shorter lengths are required to facilitate tray assembly.
5. Rung Spacing: 9 inches for data and signal trays; 18 inches o.c. for power trays.
6. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
7. Minimum Cable-Bearing Surface for Rungs: 7/8-inch width with radius edges.
8. No portion of the rungs shall protrude below the bottom plane of side rails.
9. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
10. Fitting Minimum Radius: 12 inches for data and signal trays; 24 inches for 480V power trays; and 36 inches for 5 and 15 kV trays.
11. Class Designation: Comply with NEMA VE 1, Class 20B.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.

13. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

14. Covers: Ventilated-hat, 2-in-3 pitch type made of same materials and with same finishes as cable tray where indicated.

C. Materials and Finishes:

1. Aluminum:

a. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 according to ANSI H35.1/H 35.1M for fabricated parts.

b. Hardware: Chromium-zinc-plated steel, ASTM F 1136.

c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

2. Stainless Steel:

a. Materials: Low-carbon, passivated stainless steel, or Type 304L, ASTM F 593 and ASTM F 594.

b. Hardware for Stainless-Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

2.4 Wire-Mesh Cable Tray

A. Manufacturers: Subject to compliance with requirements, provide products for example by:

1. B-line, an Eaton business.

2. Chalfant Manufacturing Company.

3. Cooper Industries; Cooper B-Line; GS Metals Corp.

4. Cope Cable Tray; A Part of Atkore International.

5. Hubbell Incorporated; Wiring Device-Kellems.

6. Legrand US.

7. MP Husky USA Cable Tray & Cable Bus.

8. Cablefil.

9. GS Metals; Globeflex.

B. Description:

1. Configuration: Galvanized- steel wire mesh, complying with NEMA VE 1.

2. Width: As indicated on Drawings.

3. Minimum Usable Load Depth: 2 inches.

4. Straight Section Lengths: 10 feet, except where shorter lengths are required to facilitate tray assembly.

5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.

6. Class Designation: Comply with NEMA VE 1, Class 10A.

7. Splicing Assemblies: Bolted type using serrated flange locknuts.

8. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

C. Materials and Finishes:

1. Steel:

a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.

b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.

c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.

d. Finish: Electrogalvanized after fabrication, complying with ASTM B 633.

1) Hardware: Galvanized, ASTM B 633.

2.5 Single-Rail Cable Tray

A. NOT PERMITTED.

2.6 Solid-Bottom Cable Tray

A. NOT PERMITTED.

2.7 Trough Cable Tray

A. NOT PERMITTED.

2.8 Channel Cable Tray

A. NOT PERMITTED.

2.9 Cable Tray Accessories

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as for cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.10 Warning Signs

A. Lettering: 1-1/2-inch- high, black letters on yellow background, with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

B. Comply with Section 26 05 53 "Identification for Electrical Systems."

2.11 Source Quality Control

A. Testing: Test and inspect cable trays according to NEMA VE 1.

Part 3 Execution

3.1 Cable Tray Installation

A. Install cable tray and support systems according to NEMA VE 2.

B. Install cable tray as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable tray, so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Remove burrs and sharp edges from cable trays.

E. Join aluminum cable tray with splice plates; use four square-neck carriage bolts and locknuts.

F. Fasten cable tray supports to building structure and install seismic restraints.

G. Design fasteners and supports to carry cable tray, cables, and a concentrated load of 200 lb. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems."

H. Place supports, so that spans do not exceed maximum spans on schedules, and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of tray rungs.

I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

J. Support assembly to prevent twisting from eccentric loading.

K. Do not install more than one cable tray splice between supports.

L. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

M. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed recommended dimensions. Space connectors and set gaps according to applicable standard.

N. Make changes in direction and elevation using manufacturer's recommended fittings.

O. Make cable tray connections using manufacturer's recommended fittings.

P. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 26 05 01 – Electrical Testing.

Q. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

R. Install cable trays with enough workspace to permit access for installing cables.

S. Install barriers to separate cables of different systems, such as communications and data processing, security and fire alarm.

T. Install permanent covers and cover clamps, if used, after installing cable.

U. Clamp covers on cable trays installed outdoors with heavy-duty clamps.

V. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 Cable Tray Grounding

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Cable trays with electrical power conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Cable trays shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch intervals. The grounding conductor shall be No. 4/0 AWG.

D. Bond cable trays to building ground system at power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.3 Cable Installation

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten power cables on horizontal runs with cable clamps. Tighten clamps only enough to secure the cable, without indenting the cable jacket.

C. Nylon cable ties are not permitted.

D. Fasten signal, data and fire alarm cables on horizontal runs with cable clamps or metallic cable ties. Do not damage jackets.

E. Fasten cables on vertical runs to cable trays every 18 inches.

F. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.

3.4 Connections

A. Connect raceways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.5 Field Quality Control

A. Perform the following tests and inspections:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.

2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.

3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.

4. Verify that there are no intruding items, such as pipes, hangers, or other equipment, in the cable tray.

5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.

6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.

7. Check for improperly sized or installed bonding jumpers.

8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.

9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 Protection

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.

2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.

3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Direct-buried conduit, ducts, and duct accessories.

2. Concrete-encased conduit, ducts, and duct accessories.

3. Handholes and boxes.

4. Manholes.

1.2 Definitions

A. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

B. RNC: Rigid nonmetallic conduit allowed only in underground concrete duct banks unless otherwise specified.

1.3 Submittals

A. Product Data: For each type of product.

1. Duct-bank materials, including separators and miscellaneous components.

2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.

3. Include accessories for manholes, handholes, boxes, and other utility structures.

4. Warning tape.

5. Warning planks.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:

a. Duct entry provisions, including locations and duct sizes.

b. Reinforcement details.

c. Frame and cover design and manhole frame support rings.

d. Ladder/Step details.

e. Grounding details.

f. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.

g. Joint details.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:

a. Include duct entry provisions, including locations and duct sizes.

b. Include cover design.

c. Include grounding details.

d. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.4 Quality Assurance

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

B. Comply with ANSI C2.

C. Comply with NFPA 70.

1.5 Delivery, Storage, and Handling

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

1.6 Project Conditions

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Owner's Representative no fewer than 10 days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without Owner's Representative's written permission.

B. Ground Water: Assume ground water is at grade level unless a lower water table is noted on the Drawings or specifications.

1.7 Coordination

A. Coordinate layout and installation of ducts, handholes, manholes and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into handholes, manholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to handholes, and as approved by Owner's Representative.

Part 2 Products

2.1 Conduit

A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.

B. RNC (only allowed in underground concrete duct banks): NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 Nonmetallic Ducts and Duct Accessories

A. Underground Ducts: NEMA TC 2, UL 651, ASTM F 512, UL 651, Type EPC-40-PVC and Type EPC-80-PVC, as indicated, with matching fittings by same manufacturer as the duct, complying with NEMA TC 3 and UL 514B.

B. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts used, and selected to provide minimum duct spacing indicated while supporting ducts during concreting or backfilling.

2. Warning Tape: Underground-line warning tape specified in Section 26 05 53 - Identification for Electrical Systems.

C. Warning Tape

1. Tape:

a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.

b. Printing on tape shall be permanent and shall not be damaged by burial operations.

c. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils

2. Color and Printing:

a. Comply with ANSI Z535.1 through ANSI Z 535.5.

b. Inscriptions for red-colored tape: ELECTRIC LINE – HIGH VOLTAGE.

c. Inscriptions for orange-colored tape: COMMUNICATIONS CABLE.

D. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 Precast Concrete Handholes and Boxes

A. Comply with ASTM C 858 for design and manufacturing processes.

B. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.

1. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.

a. Cover Hinges: Concealed, with hold-open ratchet assembly.

b. Cover Handle: Recessed.

2. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

3. Cover Legend: Molded lettering, as indicated for each service.

4. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.

5. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

a. Extension shall provide increased depth of 12 inches.

b. Slab: Same dimensions as bottom of enclosure and arranged to provide closure.

6. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground water level at grade.

7. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.

b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie into concrete envelopes of duct banks.

c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.

8. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

a. Type and size shall match fittings to duct or conduit to be terminated.

b. Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.

9. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.4 Precast Manholes

A. Comply with ASTM C 858.

B. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

C. Precast Manholes: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

D. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

1. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.

2. Window opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie into concrete envelopes of duct banks.

3. Window openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.

E. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

1. Type and size shall match fittings to duct or conduit to be terminated.

2. Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes to facilitate racking of cable.

F. Concrete Knockout Panels: 1-1/2 to 2 inches thick, for future conduit entrance and sleeve for ground rod.

G. Ground Rod Sleeve: Provide a 3-inch (RGS is preferred instead of PVC) conduit sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the ducts routed from the facility.

H. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.5 Utility Structure Accessories

A. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter 29 inches.

a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.

2. Cover Legend: Cast in. Selected to suit system.

a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.

b. Legend: “COMMUNICATIONS” for duct systems with telecommunications, alarm, control and fiber optic circuits.

3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.

a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. where packaged mix complying with ASTM C 387, Type M, may be used.

b. Seal joints watertight using preformed plastic or rubber conforming to ASTM C 990. Install sealing material according to the sealant manufacturers' printed instructions.

B. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.

C. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch diameter eye, and 1-by-4-inch bolt.

1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000 lbf minimum tension.

D. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch diameter eye, rated 2500-lbf minimum tension.

E. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.

1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.

F. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.

G. Ground Rod Sleeve: 3-inch, (RGS is preferred instead of PVC) conduit sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the ducts routed from the facility.

H. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.

I. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.

1. Stanchions: Nominal 36 inches high by 4 inches wide, with minimum of nine holes for arm attachment.

2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches with 450-lb minimum capacity to 20 inches with 250-lb minimum capacity. Top of arm shall be nominally 4 inches wide, and arm shall have slots along full length for cable ties.

J. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

K. Removable Duct Sealing System: for ducts with power cables, use Raychem RDSS Duct Sealing System at all risers into equipment and building entries.

L. Portable Manhole Ladders: UL-listed, heavy-duty fiberglass specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches. One required of each size.

M. Cover Hooks: Heavy duty, designed for lifts of 60 lbf and greater. Two required.

2.6 Source Quality Control

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.

2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.

3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

Part 3 Execution

3.1 Preparation

A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

C. Clear and grub vegetation to be removed and protect vegetation to remain. Remove and stockpile topsoil for reapplication.

3.2 Underground Duct Application

A. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank unless otherwise indicated.

B. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-80-PVC, in concrete-encased duct bank unless otherwise indicated.

C. Ducts for Control and Communications Circuits: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank unless otherwise indicated.

D. Underground Ducts Crossing Paved Paths, Walkways, Driveways, and Roadways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.3 Underground Enclosure Application

A. Handholes and Boxes for 600 V and Less:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.

2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.

3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-15 structural load rating or Polymer concrete units, SCTE 77, Tier 15 structural load rating.

4. Cover design load shall not exceed the design load of the handhole or box.

B. Manholes: Precast concrete.

1. H-20 structural load rating according to AASHTO HB 17.

3.4 Earthwork

A. Excavation and Backfill: do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching.

D. Cut and patch existing pavement in the path of underground ducts and utility structures.

3.5 Duct Installation

A. Install ducts according to NEMA TCB 2.

B. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes, to drain in both directions.

C. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use RGSC manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.

D. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

E. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line.

2. Direct-Buried Duct Banks (concrete-encased duct banks are preferred): Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct banks with calculated expansion of more than 3/4 inch.

3. Grout end bells into structure walls from both sides to provide watertight entrances.

F. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet outside the building wall, without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition.

G. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

H. Pulling Cord: Install 100-lbf- test nylon cord in empty ducts.

I. Concrete-Encased Ducts: Support ducts on duct separators.

1. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Section 31 23 33 - Trenching and Backfilling for pipes less than 6 inches in nominal diameter.

2. Width: Excavate trench 6 inches wider than duct bank on each side.

3. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.

4. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.

5. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than five spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.

6. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 18 inches between power and signal ducts.

7. Elbows: Use manufactured duct elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run unless otherwise indicated. Extend concrete encasement throughout length of elbow.

8. Elbows: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.

   a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete.

b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.

9. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.

10. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.

11. Concrete Cover: Install a minimum of 3 inches of concrete cover at top and bottom, and a minimum of 3 inches on each side of duct bank.

12. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.

    a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations or use other specific measures to prevent expansion-contraction damage.

    b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches concrete on both sides of joint near corners of envelope.

13. Pouring Concrete: Place concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

J. Direct-Buried Duct Banks (Concrete-encased duct banks are preferred):

1. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms for pipes less than 6 inches in nominal diameter.

2. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.

3. Space separators close enough to prevent sagging and deforming of ducts, with not less than five spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.

4. Depth: Install top of duct bank at least 36 inches below finished grade unless otherwise indicated.

5. Set elevation of bottom of duct bank below frost line.

6. Install ducts with a minimum of 3 inches between ducts for like services and 24 inches between power and signal ducts.

7. Elbows: Install manufactured duct elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.

8. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.

   a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete.

   b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

9. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Division 31 Sections and other Civil/Sitework Specifications for installation of backfill materials.

   a. Place minimum 3 inches of sand as a bed for duct bank. Place sand to a minimum of 6 inches above top level of duct bank.

   b. Place minimum 6 inches of engineered fill above concrete encasement of duct bank.

K. Warning Tape: Bury warning tape approximately 12 inches below finished grade above all duct banks. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.6 Installation of Concrete Manholes, Handholes, and Boxes

A. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891 unless otherwise indicated.

2. Install units, level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances.

3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.

2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.

3. Install handholes with bottom below frost line, 15 inches minimum below grade.

4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.

5. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.

2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

E. Waterproofing: Apply elastomeric sheet waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. After ducts have been connected and grouted, and before backfilling, waterproof joints, and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

F. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

G. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

H. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 Grounding

A. Comply with IEEE C2 grounding requirements.

B. Ground underground ducts and utility structures according to Section 26 05 26 - Grounding and Bonding for Electrical Systems.

3.8 Field Quality Control

A. Perform the following tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.

2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 6-inch long mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.

3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26 - Grounding and Bonding for Electrical Systems. Ground resistance shall be 10 ohms or less as tested by the 2-point fall of potential method.

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.9 Cleaning

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.
6. Penetrations in fire-resistance-rated walls.
7. Penetrations in horizontal assemblies.
8. Penetrations in smoke barriers.

1.2 Action Submittals

A. Product Data: For each type of product.

B. Product Test Reports: For each penetration firestopping system, for tests performed by a qualified testing agency.

1.3 Closeout Submittals

A. Installer Certificates: From Installer indicating that penetration firestopping systems have been installed in compliance with requirements and manufacturer's written instructions.

1.4 Quality Assurance

A. Installer Qualifications: A firm that has been approved by FM Global according to FM Global 4991, "Approval of Firestop Contractors," or been evaluated by UL and found to comply with its "Qualified Firestop Contractor Program Requirements."

1.5 Project Conditions

A. Environmental Limitations: Do not install penetration sealants or firestopping when ambient or substrate temperatures are outside limits permitted by sealing system manufacturers or when substrates are wet because of rain, frost, condensation, or other causes.

B. Install and cure penetration sealing materials per manufacturer's written instructions using natural means of ventilations or, where this is inadequate, forced-air circulation.

1.6 Coordination

A. Coordinate construction of openings and penetrating items to ensure that penetration sealing systems can be installed according to manufacturer’s requirements and applicable listings.

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

Part 2 Products

2.1 Sleeves

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.

2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.

b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 Sleeve-Seal Systems

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

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

a. Advance Products & Systems, Inc.

b. CALPICO, Inc.

c. Metraflex Company (The).

d. Pipeline Seal and Insulator, Inc.

e. Proco Products, Inc.

2. Sealing Elements: Nitrile (Buna N) rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

3. Pressure Plates: Stainless steel.

4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.3 Sleeve-Seal Fittings

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

2.4 Grout

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 Sealants

A. Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 200 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals. American Polywater Corporation, FST Foam Sealant.

C. Removable Duct Sealing System: for ducts with power cables, use Raychem RDSS Duct Sealing System at all risers into equipment and building entries.

2.6 Penetration Firestopping Systems

A. Penetration Firestopping Systems: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration firestopping systems shall be compatible with one another, with the substrates forming openings, and with penetrating items if any.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following listed by UL and FM Global:

a. 3M Fire Protection Products.

b. A/D Fire Protection Systems Inc.

c. Hilti, Inc.

d. HOLDRITE.

e. NUCO Inc.

f. Passive Fire Protection Partners.

g. RectorSeal.

h. Specified Technologies, Inc.

B. Penetrations in Fire-Resistance-Rated Walls: Penetration firestopping systems with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg.

1. F-Rating: Not less than the fire-resistance rating of constructions penetrated.

C. Penetrations in Horizontal Assemblies: Penetration firestopping systems with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg.

1. F-Rating: At least one hour, but not less than the fire-resistance rating of constructions penetrated.

2. T-Rating: At least one hour, but not less than the fire-resistance rating of constructions penetrated except for floor penetrations within the cavity of a wall.

D. Penetrations in Smoke Barriers: Penetration firestopping systems with ratings determined per UL 1479, based on testing at a positive pressure differential of 0.30-inch wg.

E. Exposed Penetration Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, per ASTM E 84.

F. Accessories: Provide components for each penetration firestopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration firestopping system manufacturer and approved by qualified testing and inspecting agency for conditions indicated.

1. Permanent forming/damming/backing materials.
2. Substrate primers.
3. Collars.
4. Steel sleeves.

2.7 Fill Materials

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

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

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

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

E. Intumescent Putties: Nonhardening, water-resistant, intumescent putties containing no solvents or inorganic fibers.

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

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

H. Pillows/Bags: Reusable heat-expanding pillows/bags consisting of glass-fiber cloth cases filled with a combination of mineral-fiber, water-insoluble expansion agents, and fire-retardant additives. Where exposed, cover openings with steel-reinforcing wire mesh to protect pillows/bags from being easily removed.

I. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

J. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants.

Part 3 Execution

3.1 Sleeve Installation for Non-Fire-Rated Electrical Penetrations

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

    a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.

    b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall, so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

3. Size pipe sleeves to provide 1/4-inch minimum, ½-inch maximum, annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.

4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.

5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level unless otherwise indicated. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.

2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install steel sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 Sleeve-Seal-System Installation

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 Sleeve-Seal-Fitting Installation

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.4 Installation

A. General: Install penetration firestopping systems to comply with manufacturer's written installation instructions and published drawings for products and applications.

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

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

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

1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items to achieve required fire-resistance ratings.

2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.

3. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels, including arc-flash warning labels.
8. Miscellaneous identification products.

1.2 Action Submittals

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use designations indicated on Drawings for signage.

D. Delegated-Design Submittal: For arc-flash hazard study.

Part 2 Products

2.1 Performance Requirements

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 86 deg F, ambient; 180 deg F, material surfaces, ± 100 deg F.

2.2 Color and Legend Requirements

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.

2. Legend: Indicate voltage and system or service type.

B. Raceways and Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.

2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

C. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.3 Labels

A. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering comparable products that may be incorporated into the Work include, but are not limited to, the following:

a. Brady Corporation.

b. Champion America.

c. Emedco.

d. Grafoplast Wire Markers.

e. LEM Products Inc.

f. Marking Services, Inc.

g. Panduit Corp.

h. Seton Identification Products.

B. Snap-Around Labels for Raceways and Cables Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceways they identify, and that stay in place by gripping action.

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

a. Brady Corporation.

b. Marking Services, Inc.

c. Panduit Corp.

d. Seton Identification Products.

C. Self-Adhesive Labels:

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

a. Brady Corporation.

b. Brother International Corporation.

c. Emedco.

d. Grafoplast Wire Markers.

e. Ideal Industries, Inc.

f. LEM Products Inc.

g. Marking Services, Inc.

h. Panduit Corp.

i. Seton Identification Products.

2. Preprinted, 3-mil- thick, vinyl flexible label with acrylic pressure-sensitive adhesive.

   a. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized to fit the cable or raceway diameter, such that the clear shield overlaps the entire printed legend.

3. Vinyl, thermal, transfer-printed, 3-mil- thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

   a. Nominal Size: 3.5-by-5-inch.

4. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

5. Marker for Tags: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 Bands and Tubes

A. Snap-Around, Color-Coding Bands for Raceways and Cables: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters of raceways or cables they identify, and that stay in place by gripping action.

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

      a. Brady Corporation.

      b. Marking Services, Inc.

      c. Panduit Corp.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around cables they identify. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

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

      a. Brady Corporation.

      b. Panduit Corp.

2.5 Tapes and Stencils

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

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

a. Carlton Industries, LP.

b. Champion America.

c. Ideal Industries, Inc.

d. Marking Services, Inc.

e. Panduit Corp.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

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

a. Brady Corporation.

b. Carlton Industries, LP.

c. Emedco.

d. Marking Services, Inc.

C. Floor Marking Tape: 2-inch- wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

D. Underground-Line Warning Tape

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

a. Brady Corporation.

b. Ideal Industries, Inc.

c. LEM Products Inc.

d. Marking Services, Inc.

e. Reef Industries, Inc.

f. Seton Identification Products.

2. Tape:

a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.

b. Printing on tape shall be permanent and shall not be damaged by burial operations.

c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. Color and Printing:

a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.

b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".

c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

d. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.

e. Width: 3 inches.

f. Overall Thickness: 5 mils.

g. Foil Core Thickness: 0.35 mil.

h. Weight: 28 lb/1000 sq. ft.

i. Tensile according to ASTM D 882: 70 lbf and 4600 psi.

2.6 Tags

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

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

    a. Brady Corporation.

    b. Carlton Industries, LP.

    c. Emedco.

    d. Marking Services, Inc.

    e. Seton Identification Products.

2.7 Signs

A. Baked-Enamel Signs:

1. Preprinted aluminum signs punched or drilled for fasteners, with colors, legend, and size required for application.

2. 1/4-inch grommets in corners for mounting.

3. Nominal Size: 7 by 10 inches.

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

    a. Carlton Industries, LP.

    b. Champion America.

    c. Emedco.

    d. Marking Services, Inc.

B. Metal-Backed Butyrate Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing and with colors, legend, and size required for application.

2. 1/4-inch grommets in corners for mounting.

3. Nominal Size: 10 by 14 inches.

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

    a. Carlton Industries, LP.

b. Champion America.

c. Emedco.

d. Marking Services, Inc.

C. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.

2. Thickness:

a. For signs up to 20 sq. inches, minimum 1/16-inch.

b. For signs larger than 20 sq. inches, 1/8 inch thick.

c. Engraved legend as follows:

1) Normal Systems – black letters on white face.

2) UPS Systems – white letters on blue face.

3) Emergency Systems – white letters on red face.

d. Self-adhesive.

e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

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

a. Brady Corporation.

b. Carlton Industries, LP.

c. Emedco.

d. Marking Services, Inc.

2.8 Cable Ties

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

1. Ideal Industries, Inc.

2. Marking Services, Inc.

3. Panduit Corp.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.9 Miscellaneous Identification Products

A. Paint: Comply with requirements in Painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

Part 3 Execution

3.1 Preparation

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 Installation

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.

2. In Spaces Handling Environmental Air: Plenum rated.

I. Painted Identification: Comply with requirements in Painting Sections for surface preparation and paint application.

J. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

K. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

L. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.3 Identification Schedule

A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch- wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- high black letters on 20-inch centers. Stop stripes at legends. Apply stripes to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.

2. Wall surfaces directly external to raceways concealed within wall.

3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl labels. Install labels at 10-foot maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive vinyl label. Install labels at 10-foot maximum intervals.

D. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."

2. "NORMAL POWER."

3. "UPS."

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.

a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.

b. Colors for 208/120-V Circuits:

1) Phase A: Black.

2) Phase B: Red.

3) Phase C: Blue.

4) Neutral: White.

c. Colors for 480/277-V Circuits:

1) Phase A: Brown.

2) Phase B: Orange.

3) Phase C: Yellow.

4) Neutral: Gray.

d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

F. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.

G. Install instructional sign, including the color code for grounded and ungrounded conductors using adhesive-film-type labels.

H. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive vinyl labels with the conductor or cable designation, origin, and destination.

I. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes or self-adhesive vinyl labels with the conductor designation.

J. Conductors to be Extended in the Future: Attach marker tape to conductors and list source.

K. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

L. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

1. Install underground-line warning tape for direct-buried cables and cables in raceways.

M. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and

29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

N. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.

  1. Comply with 29 CFR 1910.145.

  2. Identify system voltage with black letters on an orange background.

  3. Apply to exterior of door, cover, or other access.

  4. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

    a. Power-transfer switches.

    b. Controls with external control power connections.

O. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.

  1. Comply with NFPA 70E and ANSI Z535.4.

  2. Comply with Section 26 05 74 - Overcurrent Protective Device Arc-Flash Study requirements for arc-flash warning labels.

P. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

Q. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer and load shedding.

R. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm unless equipment is provided with its own identification.

  1. Labeling Instructions:

    a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine plastic label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.

b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.

c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

d. Unless labels are provided with self-adhesive means of attachment, fasten them with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a self-adhesive, engraved, laminated acrylic or melamine label.

b. Enclosures and electrical cabinets.

c. Switchgear.

d. Switchboards.

e. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.

f. Substations.

g. Motor-control centers.

h. Enclosed switches.

i. Enclosed circuit breakers.

j. Enclosed controllers.

k. Variable-speed controllers.

l. Push-button stations.

m. Power-transfer equipment.

n. Contactors.

o. Remote-controlled switches, dimmer modules, and control devices.

p. Battery-inverter units.

q. Battery racks.

r. Monitoring and control equipment.

s. UPS equipment.

END OF SECTION

Part 1 General

1.1 Related Documents

A. Specifications 26 05 73 and 26 05 74 include requirements for other related electrical power system studies. All electrical power system studies shall be considered together as a whole.

1.2 Summary

A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.3 Definitions

A. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

C. SCCR: Short-circuit current rating.

D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 Action Submittals

A. Submit the following after the approval of system protective devices submittals.

1. Short-circuit study input data, including completed computer program input data sheets.

2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.

    a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

    b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

1.5 Informational Submittals

A. Qualification Data: For Short-Circuit Study Specialist.

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.6 Quality Assurance

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

Part 2 Products

2.1 Computer Software

A. Software Developers: Subject to compliance with requirements, provide software by the following:

1. SKM Systems Analysis, Inc.

B. Comply with IEEE 399 and IEEE 551.

C. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 Short-Circuit Study Report Contents

A. Executive summary.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Comments and recommendations for system improvements, where needed.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.

G. Short-Circuit Study Output:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.

b. Calculated fault-current magnitude and angle.

c. Fault-point X/R ratio.

d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.

b. Calculated symmetrical fault-current magnitude and angle.

c. Fault-point X/R ratio.

d. Calculated asymmetrical fault currents:

1) Based on fault-point X/R ratio.

2) Based on calculated symmetrical value multiplied by 1.6.

3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.

b. Calculated symmetrical fault-current magnitude and angle.

c. Fault-point X/R ratio.

d. No AC Decrement (NACD) ratio.

e. Equivalent impedance.

f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.

g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

Part 3 Execution

3.1 Examination

A. Obtain all data necessary for the conduct of the study.

1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of the Engineer.

2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.

2. Obtain electrical power utility impedance at the service.

3. Power sources and ties.

4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.

5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.

6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.

7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.

8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.

9. Motor horsepower and NEMA MG 1 code letter designation.

10. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.2 Short-Circuit Study

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:

   1. To normal system low-voltage load buses where fault current is 10 kA or less.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

   1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:

   1. Electric utility's supply termination point at service transformer.
   2. Low-voltage switchgear.
   3. Motor-control centers.
   4. Control panels.
   5. Standby generators and automatic transfer switches.
   6. Branch circuit panelboards.
   7. Disconnect switches.

3.3 Demonstration

A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION

Part 1 General

1.1 Related Documents

A. Specifications 26 05 72 and 26 05 74 include requirements for other related electrical power system studies. All electrical power system studies shall be considered together as a whole.

1.2 Summary

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1. Study results shall be used to determine coordination of series-rated devices.

1.3 Definitions

A. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

C. SCCR: Short-circuit current rating.

D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 Action Submittals

A. Other Action Submittals: Submit the following after the approval of system protective devices submittals.

1. Coordination-study input data, including completed computer program input data sheets.

2. Study and equipment evaluation reports.

3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.

   a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 Informational Submittals

A. Qualification Data: For Coordination Study Specialist.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.6 Closeout Submittals

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. In addition, include the following:

a. The following parts from the Protective Device Coordination Study Report:

1) One-line diagram.

2) Protective device coordination study.

3) Time-current coordination curves.

b. Power system data.

1.7 Quality Assurance

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

Part 2 Products

2.1 Computer Software Developers

A. Software Developers: Subject to compliance with requirements, provide software by the following:

1. SKM Systems Analysis, Inc.

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

2.2 Protective Device Coordination Study Report Contents

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 05 72 - Overcurrent Protective Device Short-Circuit Study.

F. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.

    a. Phase and Ground Relays:

        1) Device tag.

        2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.

        3) Recommendations on improved relaying systems, if applicable.

    b. Circuit Breakers:

        1) Adjustable pickups and time delays (long time, short time, ground).

        2) Adjustable time-current characteristic.

        3) Adjustable instantaneous pickup.

        4) Recommendations on improved trip systems, if applicable.

    c. Fuses: Show current rating, voltage, and class.

G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.

2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.

3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

4. Plot the following listed characteristic curves, as applicable:

    a. Power utility's overcurrent protective device.

    b. Medium-voltage equipment overcurrent relays.

    c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.

d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.

e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.

f. Cables and conductors damage curves.

g. Ground-fault protective devices.

h. Motor-starting characteristics and motor damage points.

i. Generator short-circuit decrement curve and generator damage point.

j. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Series rating on equipment allows the application of two series interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Both devices share in the interruption of the fault and selectivity is sacrificed at high fault levels. Maintain selectivity for tripping currents caused by overloads.

6. Provide adequate time margins between device characteristics such that selective operation is achieved.

7. Comments and recommendations for system improvements.

Part 3 Execution

3.1 Examination

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 Protective Device Coordination Study

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:

   1. To normal system low-voltage load buses where fault current is 10 kA or less.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:

   1. Device shall not operate in response to the following:

      a. Inrush current when first energized.

      b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.

      c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

   2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:

   1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.

   2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

K. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Switchgear.
3. Low-voltage switchgear.
4. Motor-control centers.
5. Standby generators and automatic transfer switches.
6. Branch circuit panelboards.

M. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

3.3 Load-Flow and Voltage-Drop Study

A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:

1. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
2. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.
3. Prepare the load-flow and voltage-drop analysis and report to show power system components that are overloaded or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.4 Motor-Starting Study

A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting for motors over 50 hp. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.

B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.

3.5 Power System Data

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of the Engineer.

2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.

2. Electrical power utility impedance at the service.

3. Power sources and ties.

4. Short-circuit current at each system bus, three phase and line-to-ground.

5. Full-load current of all loads.

6. Voltage level at each bus.

7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.

8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.

9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.

10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.

11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.

12. Maximum demands from service meters.

13. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.

14. Motor horsepower and NEMA MG 1 code letter designation.

15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).

16. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

17. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.

    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.

    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.

    d. Generator thermal-damage curve.

    e. Ratings, types, and settings of utility company's overcurrent protective devices.

    f. Special overcurrent protective device settings or types stipulated by utility company.

    g. Time-current-characteristic curves of devices indicated to be coordinated.

    h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.

    i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.

    j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.

k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.6 Field Adjusting

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

B. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.7 Demonstration

A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.

2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.

3. Adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION

Part 1 General

1.1 Related Documents

A. Specifications 26 05 72 and 26 05 73 include requirements for other related electrical power system studies. All electrical power system studies shall be considered together as a whole.

1.2 Summary

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 Definitions

A. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

C. SCCR: Short-circuit current rating.

D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 Action Submittals

A. Other Action Submittals: Submit the following submittals after the approval of system protective devices submittals.

1. Arc-flash study input data, including completed computer program input data sheets.

2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.

   a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 Informational Submittals

A. Qualification Data: For Arc-Flash Study Specialist.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 Closeout Submittals

A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

B. Operation and Maintenance Procedures: In addition, provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.7 Quality Assurance

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

   1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

Part 2 Products

2.1 Computer Software Developers

A. Software Developers: Subject to compliance with requirements, provide software by the following:

1. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2 Arc-Flash Study Report Content

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.

2. Cable size and lengths.

3. Transformer kilovolt ampere (kVA) and voltage ratings.

4. Motor and generator designations and kVA ratings.

5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 05 72 - Overcurrent Protective Device Short-Circuit Study.

F. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 26 05 73 "Overcurrent Protective Device Coordination Study."

G. Arc-Flash Study Output:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.

b. Calculated symmetrical fault-current magnitude and angle.

c. Fault-point X/R ratio.

d. No AC Decrement (NACD) ratio.

e. Equivalent impedance.

f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.

g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.

2. Protective device clearing time.

3. Duration of arc.

4. Arc-flash boundary.

5. Working distance.

6. Incident energy.

7. Hazard risk category.

8. Recommendations for arc-flash energy reduction.

I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

J. A devise point is primarily described by the following:

1. A 3-phase overcurrent protective device 208V and above.

a. MCC Bucket: Count each bucket with a load connected as a point.

b. Bus Plugs: Count each plug connected to a load as one point. (If no conduit attached assume as a spare.)

c. Fuse Switch: Count each fused switch with a load connected as one point.

d. Panelboard Breaker: Count each 3-phase breaker with a load connected as a point.

2. All 3-phase 208V protective devices located in a panelboard served by a 125 kVA transformer and above. Note: If a 208V panelboard is served by a 112 kVA xfmr or lower, then the breakers are not counted as points, and shall be field marked with generic Category 0 label.

3. All 3-phase transfer (208V and above).

4. All motors 40 HP and above.

5. A fused or non-fused disconnect switch or transfer switch.

6. A medium / high voltage relay (only one from each set is considered a point).

7. Each generator.

8. Each utility service.

2.3 Arc-Flash Warning Labels

A. Comply with requirements in Section 26 05 53 - Identification for Electrical Systems. Produce a 3.5-by-5-inch thermal transfer label of high-adhesion polyester for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Location designation.

2. Nominal voltage.

3. Flash protection boundary.

4. Hazard risk category.

5. Incident energy.

6. Working distance.

7. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

Part 3 Execution

3.1 Examination

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 Arc-Flash Hazard Analysis

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies:

1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 05 72 - Overcurrent Protective Device Short-Circuit Study.

2. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 26 05 73 - Overcurrent Protective Device Coordination Study.

C. Calculate maximum and minimum contributions of fault-current size.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.

2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.

2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.

2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 Power System Data

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on the one-line diagram on Drawings and under "Preparatory Studies" Paragraph in "Arc-Flash Hazard Analysis" Article. Call discrepancies to the attention of Architect.

2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.

2. Obtain electrical power utility impedance at the service.

3. Power sources and ties.

4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.

5. For reactors, provide manufacturer and model designation, voltage rating and impedance.

6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.

7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.

8. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.

9. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.

10. Motor horsepower and NEMA MG 1 code letter designation.

11. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

12. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

3.4 Labeling

A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:

1. Motor-control center.

2. Low-voltage switchboard.

3. Switchgear.

4. Transformer.

5. Control panel.

3.5 Application of Warning Labels

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.6 Demonstration

A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

3.7 Final Study Report Requirements

A. Supply a comprehensive report with all engineering materials for review that includes:

1. Report summary with analysis methodology, findings and recommendations.

2. A summary of all input data for utility source, equipment, protective devices, transformers and cables in spreadsheet format.

3. A summary of the Arc Flash Analysis in spreadsheet format which gives at a minimum, the available fault current, incident energy level (calories/cm2), hazard category at each equipment (bus) location and its protective device.

4. Overcurrent device coordination curves (TCC) including related section of the single-line diagram for any miscoordination issues or recommendations.

5. The one-line diagram created from the data collected shall be separated to fit onto E-size drawings and exported to AutoCAD format. These one-lines will be included in the final Study Report on 11 x 17 sheets. (All information shall be legible on 11 x 17 sheets.) The following information including the component or bus name shall be shown on the one-line diagram.

   a. Data values inputted into the SKM program which include:

      1) Protective Device (Manufacturer, type, size, settings, ct ratio)

      2) Cable (# conductors/phase, size, length).

      3) Transformer (primary and secondary voltage, kVA rating, percent impedance).

      4) Motor: (Name, Voltage, FLA).

   b. Equipment (bus) locations:

      1) The available fault current at each bus location which will receive an Arc Flash label.

      2) The hazard category at each bus location which will receive an Arc Flash label.

      3) The voltage level.

6. Provide one (1) CD which includes all the SKM Power Tools electrical engineering software data files of the analysis and in addition supply all information listed (in a thru e) in PDF format.

7. Provide to customer copies of all original data collection sheets with all information required to perform the engineering analysis.

8. Two (2) sets of E-size drawings of electrical one-lines exported to AutoCAD.

END OF SECTION

Part 1 General

1.1 Scope

A. The specification covers requirements applicable to the provision of Integrated Power Assembly (IPA), also known as E-House. The IPA shall be environmentally controlled and shall consist of a coordinated grouping of electrical power and controls equipment as indicated on any accompanying data sheets and/or drawings. Any data sheets, drawings, or any other related documents accompanying this specification shall be considered a part of this specification. The requirements included in this specification shall also apply and be applicable to the precast concrete building specification 13 34 00 regarding prefabricated concrete buildings utilized for e-house purposes.

B. The supplier shall furnish, install, interconnect, and test the equipment and materials specified herein, as well as any equipment specified in any related documents.

C. Site conditions shall be shown on the data sheet(s). These conditions shall be considered when sizing and designing equipment and structures.

1.2 References

A. All materials, equipment and labor supplied by the supplier shall be in strict compliance with the statutes, codes and standards listed herein. Where conflicts exist between statutes, codes and standards, the more stringent requirement shall prevail. Applicable statutes, codes and standards are as listed below:

1. American Institute of Steel Construction (AISC)
2. American National Standard Institute (ANSI)
3. American Society of Testing and Materials (ASTM)
4. American Welding Society (AWS)
    a. AWSD1.1 Structural Welding Code – Steel
5. National Fire Protection Association (NFPA)
6. National Electric Code (NEC)
7. National Electrical Manufacturers Association (NEMA)
8. Underwriters’ Laboratories (UL)
9. International Building Code (IBC)
10. State Modular Building Code Programs where applicable

11. Division 26, Electrical Specifications (all that apply)
12. Division 40, Process Control (40 60 00) Specifications
13. American Society Civil Engineers 7 (ASCE7)

1.3 Submittals – For Review/Approval

A. The supplier shall provide the following submittals:

1. Any quality plans, forms, or procedures deemed necessary by the customer.
2. Structural drawings including:
   a. General notes and inspection tables.
   b. Building plan view.
   c. Building base skid detail.
   d. Building elevations.
   e. Stairs and landings details (if applicable).
   f. Base reactions or loads transmitted to foundation system.
   g. Anchorage requirements.
   h. Certified structural calculations (if applicable).
3. Electrical drawings including:
   a. Electrical notes, symbols, and legend.
   b. Electrical one-line(s), and/or riser diagrams showing all voltages, cabling, connections, and conduit.
   c. Electrical equipment connection schedules and electrical panel schedules.
   d. Building electrical plan, showing conduit / penetrations, cable tray, subfloor wireway, and any other means of wiring transit. Drawings shall also include conduit fill.
   e. Building services wiring diagrams.
   f. Grounding system plan.
   g. Interconnection wiring diagrams.

h. Controls, SCADA, and automation connection and wiring diagrams.

1.4 Submittals – For Construction

A. The following information shall be submitted for record purposes:

1. Final as-built drawings and information for items listed in Paragraph 1.3 and shall incorporate all changes made during the manufacturing process.

2. Wiring and connection diagrams.

3. Structural calculations, signed and sealed by a Licensed Professional Engineer in the state of the project.

4. Installation information including equipment anchorage provisions.

5. Seismic certification as specified (if applicable).

1.5 Quality Requirements

A. The IPA shall be manufactured under an established autonomous quality assurance program. The supplier shall have a designated quality assurance (QA) manager.

1. The successful bidder shall be prepared to submit for customer approval, any and/or all quality plans, forms, and procedures applicable to the manufacturer of the IPA.

1.6 Qualifications

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

B. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

Part 2 Products

2.1 Integrated Power Assembly (IPA)

A. The IPA shall be designed and constructed for outdoor use, under wind and seismic load (if applicable) conditions per the IBC or State guidelines for the job site.

B. The building and all components mounted thereon shall be designed for, and anchored sufficiently for, transportation to the job site.

C. The skid shall be constructed of precast concrete or of a fully welded, steel frame.

1. Concrete construction shall consist of six-inch ribbed construction with proper rib size and spacing to meet the required floor loadings. Increased floor thickness (up to 8”) may be required to meet floor live load requirements. Properly reinforced 5000-PSI lightweight concrete should be used for all floor panels. Concrete ribs will be placed a maximum oc 48” on center. Concrete ribs will be of adequate size to resist the loadings applicable of the building design. Reinforcement should be properly placed in the concrete panel to provide adequate reinforcement, spacing and cover as required by ACI 318. Panels should be poured to include all attachments necessary to lift and fully assemble the building units. All concrete units should be poured on flat smooth steel form-work. Floor must be bolted to adjoining walls. All structures to be shipped with floor systems fully assembled to walls.

2. Steel framing shall utilize ASTM-A992 grade 50 minimum structural steel members, sized and arranged for proper strength, and able to withstand the stress and loads which will result when lifting the complete factory fabricated and equipped assemblies. Welding shall be in accordance with the requirements of AWSD1.1. All welding shall be performed by welders certified for the work being performed. Suppliers shall be prepared to show welders’ certificates.

   a. Deflection shall be L/240. The building shall be suitable for installation on a concrete pad or on piers.

   b. The skid shall be equipped with two (2) stainless steel ground pads located at opposite corners of the skid with provisions for NEMA hole pattern lug.

   c. The skid shall be provided with a minimum of 8 mils mastic undercoating.

D. The floor shall be a minimum of 1/4-inch H.R. ASTM-A36 minimum smooth steel plate, welded to the perimeter and longitudinal and/or transverse structural members of the skid. The floor loading shall be no less than 250 PSF.

1. The floor shall be provided with gasketed floor cutouts where required for power and control cable entry/exit from the equipment. The cutouts shall be provided with 12 gauge galvanized or painted cover plates.

E. Building construction:

1. Building walls, roof and ceiling shall be fabricated from properly reinforced 5000-PSI concrete. Exterior walls, exterior roof and interior ceiling shall be self-framing, interlocking design, with maximum panel width of 16-inch, or framed construction with maximum panel width of 36-inch.

2. Exterior walls shall be properly reinforced 5000-PSI concrete rated to withstand the loading requirements of the job site.

3. Interior walls shall be constructed of six-inch “ribbed” panel construction,

bolted to adjoining walls, that is properly reinforced 5000-PSI lightweight concrete rated to withstand the loading requirements of the job site.

4. Exterior roof shall be properly reinforced 5000-PSI concrete rated to withstand the loading requirements of the job site. The roof shall be sloped away from the personnel doors, where feasible. Gutters and downspouts shall be provided when the roof slope is directly over personnel or rear access equipment doors.

5. Interior ceiling shall be properly reinforced 5000-PSI concrete rated to withstand the loading requirements of the job site.

F. For a building which must be shipped in multiple shipping sections, miscellaneous NEMA 1 junction boxes will be provided at the shipping splits for easy breakdown of the building wiring for shipment and reconnection at the job site. Prior to shipment the open end/sides of each shipping section will be crated (weatherproofed) for transit to the job site. The crating must be performed by a company recognized and experienced in the trade which includes the IPA manufacturer.

G. Where wall bulkhead penetrations are required, the cutouts shall be completely framed with 1/4” aluminum cover plates with neoprene gasket.

H. All fastening hardware shall be zinc-plated, stainless steel or aluminum. Welding of galvanized steel and rivets shall not be the primary method of exterior fastening. Rivets can be used for mounting non-load-bearing trim members.

I. The building shall be provided with a minimum of two (2) entrance doors. The doors shall be double wall construction, with brushed aluminum panic hardware with cylinder lock and thumb latch, brushed aluminum automatic closure with built-in hold open device, prime coat or stainless-steel hinges, threshold, weather-stripping, drip shields/water flashing, “DANGER, HIGH VOLTAGE, KEEP OUT” sign, and a 12-inch removable transom above the equipment door, when required. The personnel door shall be 36-inch x 84-inch. The equipment door shall be 48-inch x 84-inch.

1. When specified, the supplier shall provide landings and stairs for the building. The stairs shall be built in compliance with the UBC code and shall be hot-dipped galvanized after fabrication.

J. For equipment requiring rear access, the supplier shall provide 14-guage minimum galvanized steel, gasketed and hinged equipment rear access doors, with 3-point latching system with galvanized pad lockable handles, “DANGER HIGH VOLTAGE” sign, and drip shields/water flashing.

K. The walls, roof and floor shall be fully insulated, with a minimum of R-11 insulation. The walls and roof shall be provided with fiberglass batt type insulation, minimum R-11. The floor shall be provided with polyurethane spray foam insulation, minimum R-6.

L. The building shall be provided with a paint system per the following:

1. The skid shall be prepared to the appropriate SSPC standard (SSPC-1, SSPC-2, SSPC-3) for removal of rust and scale prior to painting. A 2-3 mil application of Zinc rich primer shall be provided.

2. The floor shall be provided with a 2-3 mil application of “Red” epoxy iron oxide primer, followed by a 2-3 mil application of ANSI-61 gray epoxy, with a non-skid finish

3. The exterior and interior of the building shall be provided with a 0.3-0.6 mil application of a vinyl wash primer, followed by a 2-3 mil application of white epoxy paint

M. The building shall be provided with a HVAC system, sized, and provided by the supplier, considering the ambient site conditions, the dimensions of the building, the solar heating of the building, and the heat generated by the equipment within the building. The system shall be designed such that the sensible cooling capacity, NOT the total cooling capacity, will maintain an ambient temperature within the building of between 60°F winter and 80°F summer at design conditions. The system shall be provided with an electronic, automatic changeover thermostat. When the building is specified to be located in a classified environment, the supplier shall provide an HVAC/Pressurization system in strict compliance with NFPA 496 requirements. In the event of a classified installation, the supplier shall also provide all exterior electrical apparatuses and proper seals, which are rated for use in the environment in which the building shall be installed.

N. The supplier shall furnish all electrical distribution equipment necessary for the proper operation of building services within and without the building including MCC units. The operating voltage of all distribution equipment shall be 208/120V, three-phase. The primary side of any distribution transformers and heavy-duty equipment, such as, motors, VFDs, starters, etc., shall be 480V, three-phase, unless otherwise specified on plans. Xylem (Flygt) will provide all VFD’s required and will ship to building’s manufacturing fabrications shop for installation. See electrical drawings and electrical power plan of proposed building(s) layout and required equipment. All electrical distribution equipment (480V/208/120V) will be provided and installed according to the following electrical specifications that apply:

1. Short Circuit Studies (26 05 73.13).

2. Coordination Studies (26 05 73.16).

3. Arc Flash Hazard Analysis (26 05 73.19).

4. Low-Voltage Distribution Transformers (26 22 13).

5. Panelboards (26 24 16).

6. Motor Control Centers (26 24 19).

7. Enclosed Switches and Circuit Breakers (26 28 16).

8. Manual and Magnetic Motor Controllers (26 29 13.03).

9. Variable Frequency Motor Controllers (26 29 23).

10. Surge Protection for Low-Voltage Electrical Power Circuits (26 43 13).

O. The building shall be provided with twin tube, rapid start, led lighting fixtures, controlled via three-way wall switches to be located at each entry door. Lighting will be provided and installed according to Interior Lighting 26 51 00 specifications.

P. The building shall be provided with 125V, 20A duplex receptacles at each entry door. Receptacles and other wiring devices will be provided and installed according to Wiring Devices 26 27 26 specifications and as designated on plans.

Q. The building shall be provided with LED exterior lights at each entry door, controlled via photocell and H-O-A switch. All exterior lighting will be provided and installed according to LED Exterior Lighting 26 56 19 specifications.

R. All wiring shall be type THWN, #12 AWG minimum for power circuits, minimum #14 AWG for control circuits. For all control interconnection wiring, both ends of the wire shall be provided with polyolefin sleeve type wire markers. All power cables and connections shall be provided and installed according to Low-Voltage Electrical Power Conductors and Cables 26 05 19 specifications. All controls cables and connections shall be provided and installed according to Control-Voltage Electrical Power Cables 26 05 23 specifications.

S. EMT conduit shall be utilized for interior applications unless RGS is preferred. Also, under the floor raceways are allowed. RGS conduit shall be utilized for outdoor applications. PVC will be allowed only in underground encased concrete duct banks. All raceways will be provided and installed according to Raceways and Boxes for Electrical Systems 26 05 33 specifications and Underground Ducts and Raceways for Electrical Systems 26 05 43.

T. Any cable tray necessary shall be aluminum, 6-inch high with 9-inch rung spacing. All fittings shall have a minimum of 12-inch radius. All cable trays provided will be installed according to Cable Trays for Electrical Systems 26 05 36 specifications. Under the floor raceways are a preferred option to overhead cable trays.

U. 1/4-inch x 2-inch copper ground bar running the length of the building shall be provided, mounted approximately 6-inch above floor and connected to each end of the equipment ground bar. A #4/0 green insulated copper ground cable shall be provided from the ground bar to the exterior ground pads. A green insulated copper ground wire/cable will be provided from the ground bar to all auxiliary electrical equipment per NEC Table 250-95. All equipment, panels, and cabinets will be properly grounded according to Grounding and Bonding for Electrical Systems 26 05 26 specifications.

Part 3 Execution

3.1 Testing And Inspection

A. The following testing and inspection shall be performed on the building in accordance with Electrical Testing 26 05 01 specifications:

1. Continuity checks of all wiring installed by the supplier.

2. Operational check of all suppliers furnished and installed electrical apparatuses.

3. Switchgear and Motor Control Center shipping sections' bus shall be re-spliced and torqued with megger testing.

4. A certified test report shall be provided by the supplier's Quality Assurance Manager.

5. Secondary controls power shall be provided for customer use by the supplier. Available controls power shall be 208/120V, 3-phase.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Pad-mounted, liquid-filled, medium-voltage transformers.

1.2 Preinstallation Meetings

A. Preinstallation Conference: Conduct conference at Project site.

B. Preinstallation Coordination Meeting(s): Conduct meeting(s) as videoconference or at Project site.

1.3 Action Submittals

A. Product Data: For each type of product.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.

2. Product Certificates: Include product certificate stating compliance with IEEE C57.12.00, signed by manufacturer or fabricator.

B. Factory test reports.

C. Shop Drawings: Prepare and submit the following:

1. Include plans and elevations showing major components and features.

   a. Include plan view and cross section of equipment base, showing clearances, required workspace, and locations of penetrations for grounding and conduits.

2. Include details of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connections.

3. Include single-line diagram.

4. Include list of materials.

5. Include nameplate data.

6. Manufacturer's published time-current curves of transformer line-side fuses, with transformer damage curve, inrush curve, and thru fault current indicated.

D. Field quality-control reports.

1.4 Informational Submittals

A. Manufacturer's published instructions.

B. Manufacturer's field reports for field quality-control support.

C. Field reports for voltage monitoring and adjusting.

D. Field reports for infrared scanning.

1.5 Qualifications

A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.

B. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.

Part 2 Products

2.1 Performance Requirements

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 Pad-Mounted, Liquid-Filled, Medium-Voltage Transformers

A. Source Quality Control:

1. Factory Tests:

a. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

b. Factory Tests and Inspections: Perform the following tests and inspections on transformer, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with IEEE C57.12.00 before delivering to site. Affix label with name and date of manufacturer's certification of system compliance.

1) Resistance.

2) Turns ratio, polarity, and phase relation.

3) Transformer no-load losses and excitation current at 100 percent of ratings.

4) Transformer impedance voltage and load loss.

5) Operation of devices.

6) Lightning impulse.

7) Low frequency.

8) Leak.

9) Perform Optional Tests:

a) Transformer no-load losses and excitation current at 110 percent of ratings.

b) Insulation power factor.

c) Applied potential, except that this test is not required for single-phase transformers or for three-phase Y-Y-connected transformers.

d) Induced potential.

e) Resistance measurements of windings on rated voltage connection and at tap extreme connections.

f) Ratios on rated voltage connection and at tap extreme connections.

g) Polarity and phase relation on rated voltage connection.

h) No-load loss at rated voltage on rated voltage connection.

i) Exciting current at rated voltage on rated voltage connection.

j) Impedance.

c. Nonconforming Work:

1) Equipment that does not pass tests and inspections will be considered defective.

d. Factory Test Reports: Compile and submit factory test and inspection reports.

B. Three-Phase, Pad-Mounted Transformers

1. Approved Manufacturer: Cooper or equal.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

   a. Transformers, Distribution, Liquid-Filled Type, Over 600 V: UL CCN XPLH; including IEEE C57.12.00 and IEEE C57.12.28.

3. Standard Features:

   a. Less-flammable-liquid-filled, two-winding, 60 Hz, 65 deg C rise above 30 deg C average ambient, self-cooled transformer.

   b. Reference Standards: IEEE C2 and IEEE C57.12.26.

   c. Windings Material: Copper.

   d. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, fully shielded, separable-elbow type, suitable for plugging into inserts provided in line-side section of transformer. Connected in each phase of incoming circuit and ahead of disconnecting device.

   e. Winding Connections: Connection of windings and terminal markings must comply with IEEE C57.12.70.

   f. Efficiency: Comply with 10 CFR 431, Subpart K.

   g. Insulation: Transformer kVA rating must be as follows: Average winding temperature rise above 30 deg C ambient temperature must not exceed 65 deg C and 80 deg C hottest-spot temperature rise at rated kVA when tested in accordance with IEEE C57.12.90, using combination of connections and taps that give highest average winding temperature rise.

   h. Tap Changer: External handle, for de-energized operation.

   i. Tank: Sealed, with welded-on cover. Designed to withstand internal pressure of not less than 7 psi (50 kPa) without permanent distortion and 15 psig (104 kPa) without rupture. Comply with IEEE C57.12.36.

   j. Enclosure Integrity: Comply with IEEE C57.12.28 for pad-mounted enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to public.

k. Mounting: Integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.

l. Insulating Liquids:

1) Less-Flammable Liquids:

a) Edible-Seed-Oil-Based Dielectric: Listed and labeled by qualified electrical testing laboratory recognized by authorities having jurisdiction as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested in accordance with ASTM D92. Liquid must be biodegradable and nontoxic, having passed Organisation for Economic Co-operation and Development G.L.203 with zero mortality, and must be certified by U.S. Environmental Protection Agency as biodegradable, meeting Environmental Technology Verification requirements.

b) Biodegradable and Nontoxic Dielectric: Listed and labeled by qualified electrical testing laboratory recognized by authorities having jurisdiction as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested in accordance with ASTM D92.

m. Sound level must comply with NEMA TR 1 requirements.

n. Corrosion Protection:

1) Base and Cabinets of Two Compartment Transformers: Fabricate from stainless steel in accordance with ASTM A167, Type 304 or 304L, not less than No. 13 U.S. gage. Coat transformer with manufacturer's standard green color coating complying with requirements of IEEE C57.12.28, IEEE C57.12.29, in manufacturer's standard color green.

o. Compartment Construction:

1) Double-Compartment Construction: Individual compartments for line- and load-side sections, formed by steel isolating barriers that extend full height and depth of compartments, with hinged, lift-off doors and three-point latching, with stop in open position and provision for padlocking.

p. Primary Fusing: Designed and rated to provide thermal protection of transformer by sensing overcurrent and high liquid temperature.

1) 150 kV BIL current-limiting fuses, conforming to requirements of IEEE C37.47.

2) Interrupting Rating: 50 000 A(rms sym) at system voltage.

3) Fuse Assembly: Bayonet-type, liquid-immersed, expulsion fuses in series with liquid-immersed, partial-range, current-limiting fuses. Bayonet fuse must sense both high currents and high oil temperature to provide thermal protection to transformer. Connect current-limiting fuses ahead of radial-feed load-break switch.

4) Provide bayonet fuse assembly with oil retention valve and external drip shield inside housing to eliminate or minimize oil spills. Valve must close when fuse holder is removed and external drip shield is installed.

5) Provide conspicuously displayed warning adjacent to bayonet fuse(s), cautioning against removing or inserting fuses unless transformer has been de-energized and tank pressure has been released.

q. Line-Side Section: Dead-front design.

1) To connect primary cable, use separable insulated connectors; coordinated with and complying with requirements of Section 260513 "Medium-Voltage Cables." Bushings must be one-piece units, with ampere and BIL ratings same as connectors.

2) Bushing inserts and feed-through inserts:

a) Conform to requirements of IEEE 386.

b) Rated at 200 A, with voltage class matching connectors. Provide parking stand near bushing wells. Parking stands must be equipped with insulated standoff bushings for parking of energized load-break elbow connectors on parking stands.

c) Provide insulated protective caps for insulating and sealing out moisture from unused bushing inserts and insulated standoff bushings.

3) Bushing wells configured for loop-feed application.

4) Access to liquid-immersed fuses.

5) Dead-front surge arresters.

6) Tap-changer operator.

7) Ground pad.

r. Load-Break Switch:

1) Radial-feed, liquid-immersed type with voltage class and BIL matching that of separable connectors, with continuous current rating and load-break rating of 200 A, and make-and-latch rating of 12 kA(rms sym).

2) Loop-feed sectionalizing switches, using three two-position, liquid-immersed-type switches for closed transition loop-feed and sectionalizing operation. Voltage class and BIL must match that of separable connectors, with continuous current rating and load-break rating of 200 Aand make-and-latch rating of 12 kA(rms sym). Switch operation must be as follows:

a) Position I: Line A connected to line B and both lines connected to transformer.

b) Position II: Transformer connected to line A only.

c) Position III: Transformer connected to line B only.

d) Position IV: Transformer disconnected and line A not connected to line B.

e) Position V: Transformer disconnected and line A connected to line B.

s. Load-Side Section:

1) Bushings with spade terminals drilled for terminating number of conductors indicated on the Drawings, and lugs that comply with requirements of Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

t. Capacities and Characteristics:

1) Power Rating: 1500 kVA.

2) Voltage Ratings: 480Y/277 V.

3) Taps: Comply with IEEE C57.12.26 requirements

4) Transformer BIL (kV): Comply with IEEE C57.12.26 requirements.

5) Minimum Tested Impedance (Percent) at 85 deg C: 5.75.

6) Comply with FM Global Class No. 3990.

7) Comply with UL listing requirements for combination classification and listing for transformer and less-flammable insulating liquid.

u. Transformer Accessories:

1) Drain and filter connection.

2) Filling and top filter press connections.

3) Pressure-vacuum gauge.

4) Dial-type analog thermometer with alarm contacts.

5) Magnetic liquid level indicator with high and low alarm contacts.

6) Automatically resetting pressure-relief device. Device flow must be as recommended by manufacturer.[With alarm contacts and manual bleeder.]

7) Stainless steel ground connection pads.

8) Machine-engraved nameplate, made of anodized aluminum or stainless steel.

9) Sudden pressure relay for remote alarm or trip when internal transformer pressure rises at field-set rate. Provide [with] [without] seal-in delay.

v. Control Network: Support serial MS/TP and Ethernet IP communications, and able to communicate directly via TIA-485 serial networks and Ethernet 10Base-T networks as native device.

w. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events.

Part 3 Execution

3.1 Installation

A. Preinstallation Checks:

1. Verify removal of shipping bracing after placement.

2. Remove sample of insulating liquid in accordance with ASTM D923. Insulating-liquid values must comply with NETA ATS, Table 100.4. Sample must be tested for the following:

a. Dielectric Breakdown Voltage: ASTM D877 or ASTM D1816.

b. Acid Neutralization Number: ASTM D974.

c. Specific Gravity: ASTM D1298.

d. Interfacial Tension: ASTM D971.

e. Color: ASTM D1500.

f. Visual Condition: ASTM D1524.

g. Water in Insulating Liquids: Comply with ASTM D1533.

h. Power Factor or Dissipation Factor: ASTM D924.

B. Verify that grounding and bonding connections are in place. Ground (Earth) resistance may not exceed 5 Ω at transformer location.

C. Comply with manufacturer's published instructions.

D. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.

2. Electrical Maintenance: NFPA 70B.

3. Electrical Safety: NFPA 70E.

4. Commissioning of Electrical Systems: NECA NEIS 90.

5. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.

6. Communications Work: BICSI N1.

7. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.

8. Work in Confined Spaces: NFPA 350.

9. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.

10. Consult Architect for resolution of conflicting requirements.

E. Special Installation Techniques:

1. Install transformers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 260529 "Hangers and Supports for Electrical Systems."

2. Transformer must be installed level and plumb and must tilt less than 1.5 degrees while energized.

3. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's published instructions and IEEE C2.

F. Grounding and Bonding:

1. For counterpoise, use tinned bare copper cable not smaller than 4/0 AWG, buried not less than 30 inch (765 mm) below grade interconnecting grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable, with no kinks or sharp bends.

2. Fence and equipment connections may not be smaller than 4 AWG. Ground fence at gate posts and corner posts and at intervals not exceeding 10 ft (3 m). Bond gate sections to fence posts using 1/8 by 1 inch (3 by 25 mm) tinned flexible braided copper strap and clamps.

3. Make joints in grounding conductors and loops by exothermic weld or compression connector.

4. Terminate grounding and bonding conductors on common equipment grounding terminal on transformer enclosure.

5. Complete transformer tank grounding and lightning arrester connections prior to making other electrical connections.

G. Connect low-voltage wiring.

1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.

2. Bundle associated phase, neutral, and equipment grounding conductors together within transformer enclosure. Arrange conductors such that there is not excessive strain that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.

H. Terminate medium-voltage cables in incoming section of transformers.

I. Interfaces with Other Work:

1. Identification: Provide labels for transformers and associated electrical equipment.

   a. Identify field-installed conductors, interconnecting wiring, and components.

   b. Label each enclosure with engraved metal or laminated-plastic nameplate.

   c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.

2. Install transformers on cast-in-place concrete equipment base(s).

J. Protection: After installation, protect transformer from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.2 Field Quality Control

A. Administrant for Electrical Power Tests and Inspections:

1. Owner will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.

2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.

3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Field tests and inspections must be witnessed by Owner.

C. Tests and Inspections:

1. General Field-Testing Requirements:

a. Comply with provisions of "Testing and Test Methods" Chapter in NFPA 70B.

b. Perform visual and mechanical inspections and electrical tests. Certify compliance with test parameters.

c. After installing transformer but before primary is energized, verify that grounding system at transformer is tested at specified value or less.

d. After installing transformer and after electrical circuitry has been energized, test for compliance with requirements.

e. Visual and Mechanical Inspection:

1) Verify equipment nameplate data complies with the Contract Documents.

2) Inspect bolted electrical connections for high resistance using one of the following two methods:

a) Use low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.

b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.

2. Medium-Voltage Surge Arrester Field Tests:

a. Visual and Mechanical Inspection:

1) Inspect physical and mechanical condition.

2) Verify arresters are clean.

3) Verify that ground leads on devices are individually attached to ground bus or ground electrode.

b. Electrical Test:

1) Perform insulation-resistance test on arresters, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to comply with recommended minimum insulation resistance listed in that table.

2) Perform watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.

3. Liquid-Filled Transformer Field Tests:

a. Visual and Mechanical Inspection:

1) Test dew point of tank gases if applicable.

2) Inspect anchorage, alignment, and grounding.

3) Verify bushings are clean.

4) Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.

5) Verify that liquid level in tanks is within manufacturer's published tolerances.

6) Perform specific inspections and mechanical tests recommended by manufacturer.

7) Verify presence of transformer surge arresters and that their ratings are as specified.

8) Verify that as-left tap connections are as specified.

b. Electrical Tests:

1) Perform insulation-resistance tests winding-to-winding and windings-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; value of index may not be less than 1.0.

2) Perform power-factor or dissipation-factor tests on windings in accordance with test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.3.

3) Measure core insulation resistance at 500 V(dc) if core is insulated and core ground strap is removable. Core insulation-resistance values may not be less than 1 MΩ at 500 V(dc).

4) Perform power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.

5) Perform Optional Field Tests:

a) Perform turns-ratio tests at tap positions. Turns-ratio test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.

b) Perform excitation-current test on each phase. Typical excitation-current test data pattern for three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if test shows different pattern.

c) Measure resistance of windings at tap connections, and record temperature-corrected winding-resistance values in Operations and Maintenance Manual.

d) Perform applied-voltage test on line- and load-side windings-to-ground. Comply with IEEE C57.12.91, Sections 10.2 and 10.9. This test is not required for single-phase transformers and for three-phase wye-wye-connected transformers.

6) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

7) Remove sample of insulating liquid in accordance with ASTM D923, and perform dissolved-gas analysis in accordance with IEEE C57.104 or ASTM D3612.

D. Nonconforming Work:

1. Equipment and devices will be considered defective if they do not pass tests and inspections.

2. Remove and replace malfunctioning units and retest.

E. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports. Record as-left set points of adjustable devices.

F. Manufacturer Services: Engage factory-authorized service representative to supervise field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.3 Closeout Activities

A. Training:

1. With assistance from factory-authorized service representatives, train Owner's maintenance personnel on the following topics:

a. How to adjust, operate, and maintain transformer equipment.

2. Provide video recordings of training sessions to Owner.

3.4 Maintenance

A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

1. During period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at outgoing section of transformers. Use voltmeters with calibration traceable to National Institute of Science and

Technology standards and with chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.

2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

   a. Adjust transformer taps.

   b. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action is performed, until satisfactory results are obtained.

4. Field Reports for Voltage Monitoring and Adjusting: Prepare written report covering monitoring performed and corrective action taken.

B. Infrared Scanning of Transformers: Perform survey during periods of maximum possible loading. Remove necessary covers prior to inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of transformer's electrical power connections. Remove covers so joints and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.

2. Instrument: Inspect distribution systems with imaging equipment capable of detecting minimum temperature difference of 1 deg C at 30 deg C. Provide documentation of device calibration.

3. Field Reports for Infrared Scanning: Prepare certified report that identifies transformer equipment checked, testing technician, and equipment used, and that describes scanning results. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action. List results as follows:

   a. Description of equipment to be tested.

   b. Discrepancies.

   c. Temperature difference between area of concern and reference area.

   d. Probable cause of temperature difference.

   e. Areas inspected. Identify inaccessible and unobservable areas and equipment.

   f. Identify load conditions at time of inspection.

g. Provide photographs and thermograms of deficient area.

4. Act on inspection results in accordance with recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes: Distribution dry-type transformers rated 600 V and less, with capacities up to 1500 kVA.

1.2 Action Submittals

A. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.

3. Include diagrams for power, signal, and control wiring.

1.3 Informational Submittals

A. Seismic Qualification Certificates (as required): For transformers, accessories, and components, from manufacturer.

B. Field quality-control reports.

1.4 Closeout Submittals

A. Operation and maintenance data.

1.5 Delivery, Storage, and Handling

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

Part 2 Products

2.1 Manufacturers

A. Subject to compliance with requirements, provide product indicated on the Drawings or comparable product by one of the following. Also, ensure transformers with primary (12.47kV) will be equipped with both A & B loop feed connection inputs. The 480V secondary connections to allow for two secondary feeders.

1. Maddox.
2. Eaton Corporation: Electrical Sector; Cutler-Hammer Products.
3. General Electric Company.
4. Square D; a brand of Schneider Electric.

2.2 General Transformer Requirements

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Transformers Rated 15 kVA and Larger: Comply with DOE 2016 energy-efficiency levels as verified by certified prototype testing.

D. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

E. Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3 Distribution Transformers

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Cores: One leg per phase.

C. Enclosure: Ventilated.

1. NEMA 250, Type 2 unless otherwise indicated. Core and coil shall be encapsulated within resin compound to seal out moisture and air.

D. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: NSF/ANSI 49 gray.

E. Taps for Transformers 3 kVA and Smaller: One 5 percent tap above normal full capacity.

F. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

G. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

H. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

I. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

J. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.

2. Indicate value of K-factor on transformer nameplate.

3. Unit shall meet requirements of DOE 2016 with a K-factor equal to one.

K. Wall Brackets: Manufacturer's standard brackets.

L. Fungus Proofing: Permanent fungicidal treatment for coil and core.

M. Low-Sound Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 9 kVA and less: 40 dB.

2. 30 to 50 kVA: 45 dB.

3. 51 to 150 kVA: 50 dB.

4. 151 to 300 kVA: 55 dB.

2.4 Identification Devices

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 05 53 - Identification for Electrical Systems.

2.5 Source Quality Control

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at the rated voltage connections and at all tap connections.

2. Ratio tests at the rated voltage connections and at all tap connections.

3. Phase relation and polarity tests at the rated voltage connections.

4. No load losses, and excitation current and rated voltage at the rated voltage connections.

5. Impedance and load losses at rated current and rated frequency at the rated voltage connections.

6. Applied and induced tensile tests.

7. Regulation and efficiency at rated load and voltage.

8. Insulation Resistance Tests:

    a. High-voltage to ground.

    b. Low-voltage to ground.

    c. High-voltage to low-voltage.

9. Temperature tests.

Part 3 Execution

3.1 Examination

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 26 05 26 - Grounding and Bonding for Electrical Systems have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

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

3.2 Installation

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.

    1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases according to Division 03 requirements for cast-in-place concrete and anchor floor-mounted transformers according to manufacturer's written instructions, and requirements in Section 26 05 29 - Hangers and Supports for Electrical Systems.

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

3.3 Connections

A. Ground equipment according to Section 26 05 26 - Grounding and Bonding for Electrical Systems.

B. Connect wiring according to Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 Field Quality Control

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports under Section 26 05 01 - Electrical Testing.

B. Perform tests and inspections and prepare test reports.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

D. Remove and replace units that do not pass tests or inspections and retest as specified above.

E. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.

2. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

F. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 Adjusting

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 Cleaning

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.

2. Surge protection devices.

3. Disconnecting and overcurrent protective devices.

4. Instrumentation.

5. Control power.

6. Accessory components and features.

7. Identification.

B. Related Requirements

1. Section 26 05 74 - Overcurrent Protective Device Arc-Flash Study for arc-flash analysis and arc-flash label requirements.

1.2 Action Submittals

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.

1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

2. All panels and enclosures to be dead front type.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.

2. Detail bus configuration, current, and voltage ratings.

3. Detail short-circuit current rating of switchboards and overcurrent protective devices.

4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

5. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Delegated Design Submittal:

1. For arc-flash hazard analysis.

2. For arc-flash labels.

1.3 Informational Submittals

A. Field Quality-Control Reports:

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.4 Closeout Submittals

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 78 23 - Operation and Maintenance Data, include the following:

a. Routine maintenance requirements for switchboards and all installed components.

b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.

1.5 Quality Assurance

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 Delivery, Storage, and Handling

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and connect factory-installed space heaters to temporary electrical service to prevent condensation.

C. Handle and prepare switchboards for installation according to NECA 400 and NEMA PB 2.1.

1.7 Field Conditions

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

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

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

   a. Ambient Temperature: Not exceeding 104 deg F.

   b. Altitude: Not exceeding 6600 feet.

C. Unusual Service Conditions: NEMA PB 2, as follows:

1. Ambient temperatures within limits specified.

2. Altitude not exceeding 6600 feet.

D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.

2. Indicate method of providing temporary electric service.

3. Do not proceed with interruption of electric service without Owner's written permission.

4. Comply with NFPA 70E.

1.8 Coordination

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.9 Warranty

A. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.

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

Part 2 Products

2.1 Switchboards

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

1. Eaton.

2. General Electric Company.

3. Square D; by Schneider Electric.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

H. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.

2. Branch Devices: Panel mounted.

3. Sections front and rear aligned.

I. Nominal System Voltage: 480Y/277 V.

J. Main-Bus Continuous: As indicated.

K. Indoor Enclosures: Steel, NEMA 250, Type 1.

1. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a control-power transformer, with spare capacity of 25 percent, within the switchboard. Supply voltage shall be 120 V ac.

L. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

M. Barriers: Between adjacent switchboard sections.

N. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

O. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.

2. Space-Heater Power Source: Transformer, factory installed in switchboard.

P. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

Q. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

R. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

S. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.

2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated.

3. Copper feeder circuit-breaker line connections.

4. Ground Bus: 1/4-by-2-inch- hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.

5. Disconnect Links:

a. Isolate neutral bus from incoming neutral conductors.

b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.

6. Neutral Buses: 50 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

T. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

U. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.2 Surge Protection Devices

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

1. Eaton.

2. General Electric Company.

3. Square D; by Schneider Electric.

B. SPDs: Comply with UL 1449, Type 1.

C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1.

D. Features and Accessories:

1. Integral disconnect switch.

2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.

3. Indicator light display for protection status.

4. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

5. Surge counter.

E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 300 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

F. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V.

2. Line to Ground: 1200 V for 480Y/277 V.

3. Line to Line: 2000 V for 480Y/277 V.

G. SCCR: Equal or exceed 100 kA.

H. Nominal Rating: 20 kA.

2.3 Disconnecting and Overcurrent Protective Devices

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

a. Instantaneous trip.

b. Long- and short-time pickup levels.

c. Long- and short-time adjustments.

d. Ground-fault pickup level, time delay, and I squared t response.

4. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.

b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.

c. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

d. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.

e. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

f. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

2.4 Instrumentation

A. Instrument Transformers: NEMA EI 21.1, and the following:

1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.

2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; bar or window type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.

3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

a. Phase Currents, Each Phase: Plus or minus 0.5 percent.

b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.

c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.

d. Megawatts: Plus or minus 1 percent.

e. Megavars: Plus or minus 1 percent.

f. Power Factor: Plus or minus 1 percent.

g. Frequency: Plus or minus 0.1 percent.

h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.

i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.5 Control Power

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.6 Accessory Components and Features

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

2.7 Identification

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

Part 3 Execution

3.1 Examination

A. Receive, inspect, handle, and store switchboards according to NECA 400 and NEMA PB 2.1.

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.

2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.

3. Protect from moisture, dust, dirt, and debris during storage and installation.

4. Install temporary heating during storage per manufacturer's instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

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

3.2 Installation

A. Install switchboards and accessories according to NECA 400 and NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Sections.

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.

3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

5. Install anchor bolts to elevations required for proper attachment to switchboards.

6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, surge protection devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

G. Comply with NECA 1.

3.3 Connections

A. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

B. Support and secure conductors within the switchboard according to NFPA 70.

C. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.4 Identification

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.

C. Device Nameplates: Label each disconnecting, and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.

3.5 Field Quality Control

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

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. Acceptance Testing:

a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.

b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment per NFPA 70.

3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

5. Perform the following infrared scan tests and inspections, and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.

b. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Switchboard will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 Adjusting

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73 - Overcurrent Protective Device Coordination Study.

3.7 Protection

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 Demonstration

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Distribution panelboards.

2. Lighting and appliance branch-circuit panelboards.

1.2 Definitions

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

1.3 Action Submittals

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.

2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

3. All panels and enclosures to be dead front type.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.

2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.

3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.

4. Detail bus configuration, current, and voltage ratings.

5. Short-circuit current rating of panelboards and overcurrent protective devices.

6. Include evidence of NRTL listing for series rating of installed devices.

7. Include evidence of NRTL listing for SPD as installed in panelboard.

8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

9. Include wiring diagrams for power, signal, and control wiring.

10. Key interlock scheme drawing and sequence of operations.

1.4 Informational Submittals

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.5 Closeout Submittals

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 - Operation and Maintenance Data, include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.6 Maintenance Material Submittals

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

1. Keys: Two spares for each type of panelboard cabinet lock.

2. Circuit Breakers: Spares as scheduled.

1.7 Quality Assurance

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.8 Delivery, Storage, and Handling

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407 and NEMA PB 1.

1.9 Field Conditions

A. Environmental Limitations:

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

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.

    b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.

2. Altitude not exceeding 6600 feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner’s Representative no fewer than 10 days in advance of proposed interruption of electric service.

2. Do not proceed with interruption of electric service without Owner's written permission.

3. Comply with NFPA 70E.

1.10 Warranty

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

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

Part 2 Products

2.1 Panelboards Common Requirements

A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

E. Enclosures: Surface-mounted, dead-front cabinets unless otherwise indicated.

1. Rated for environmental conditions at installed location unless otherwise scheduled.

    a. Indoor Dry and Clean Locations: NEMA 250, Type 1.

    b. Outdoor Locations: NEMA 250, NEMA 4X, stainless steel.

    c. Chemical Areas: NEMA 250, Type 4X, stainless steel.

    d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

    e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids (All Plant Locations not 4X): NEMA 250, Type 12.

2. Height: 84 inches maximum.

3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.

4. Finishes:

    a. Panels and Trim: Galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat except stainless steel.

    b. Back Boxes: Same finish as panels and trim.

    c. Fungus Proofing: Where scheduled.

F. Incoming Mains:

1. Location: As scheduled; Convertible between top and bottom.

2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

G. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

a. Plating shall run entire length of bus.

b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.

3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.

5. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads where designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.

H. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.

2. Terminations shall allow use of 75 deg C rated conductors without derating.

3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.

4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.

5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.

6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

7. Sub-feed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

8. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

I. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices scheduled as “SPACE”.

J. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.

2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 Performance Requirements

A. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2.

2.3 Power Panelboards

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

1. Eaton – PRL 4.

2. General Electric Company; GE Energy Management - Electrical Distribution - Spectal.

3. Square D; by Schneider Electric – I-Line.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker or lugs only as scheduled.

E. Mains: Where indicated, provide circuit breakers UL listed for application at 100% of their continuous ampere rating in their intended enclosure.

F. Mains over 800A: shall be equipped with microprocessor-based trip units that have integral Arc Flash Reduction trip feature. The use of zone selective interlocking to emulate this function does not meet the intent of this specification and will not be allowed.

G. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

H. Branch Circuit Breakers shall be fixed mounted type equipped with electronic trip units or thermal magnetic trip units as shown on the contract drawings. If not shown on the contract drawings, branch circuit breakers 125A and larger shall be electronic trip units.

I. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.4 Lighting and Appliance Branch-Circuit Panelboards

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

1. Eaton – PRL 1/PRL 2.

2. General Electric Company; GE Energy Management - Electrical Distribution – AE Series.

3. Square D; by Schneider Electric – NQOD/NF.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only as scheduled.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.5 Load Centers – Not Permitted

2.6 Disconnecting and Overcurrent Protective Devices

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

1. Eaton.

2. General Electric Company; GE Energy Management - Electrical Distribution.

3. Square D; by Schneider Electric.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

    a. Inverse time-current element for low-level overloads.

    b. Instantaneous magnetic trip element for short circuits.

    c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Electronic Trip Circuit Breakers where scheduled:

    a. RMS sensing.

    b. Field-replaceable rating plug or electronic trip.

    c. Digital display of settings, trip targets, and indicated metering displays.

    d. Multi-button keypad to access programmable functions and monitored data.

    e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.

    f. Integral test jack for connection to portable test set or laptop computer.

    g. Field-Adjustable Settings:

        1) Instantaneous trip.

        2) Long- and short-time pickup levels.

        3) Long- and short-time adjustments.

        4) Ground-fault pickup level, time delay, and I squared T response.

3. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).

4. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).

5. Sub-feed Circuit Breakers: Vertically mounted.

6. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.

b. Breaker handle indicates tripped status.

c. UL listed for reverse connection without restrictive line or load ratings.

d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.

e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.

f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.

h. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.

i. Auxiliary Contacts: Two, SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.

j. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.

k. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

l. Multipole units enclosed in a single housing with a single handle.

m. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.

n. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.7 Identification

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.

1. Computer-generated circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.8 Accessory Components and Features

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

Part 3 Execution

3.1 Examination

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407 and NEMA PB 1.1.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 Installation

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407 and NEMA PB 1.1.

D. Equipment Mounting:

1. Attach panelboard to the vertical finished or structural surface behind the panelboard.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Mount top of trim 90 inches above finished floor unless otherwise indicated, but no breaker shall be higher than 79 inches.

G. Mount panelboard cabinet plumb and rigid without distortion of box.

H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

I. Mount surface-mounted panelboards to stainless steel slotted supports 3/4 inch in depth. Orient steel slotted supports vertically.

J. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

K. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

L. Install filler plates in unused spaces.

M. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

N. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.3 Identification

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 26 05 53 - Identification for Electrical Systems.

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.

E. Install warning signs complying with requirements in Section 26 05 53 - Identification for Electrical Systems identifying source of remote circuit.

3.4 Field Quality Control

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Do not perform optional tests. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.

c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 Adjusting

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73 - Coordination Studies.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.

2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.

3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.

4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 Protection

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

Part 1 General

1.1 Summary

A. Section includes MCCs for use with ac circuits rated 600 V and less, with combination controllers and having the following factory-installed components:

1. Feeder-tap units.

2. Measurement and control.

3. Auxiliary devices.

1.2 Definitions

A. CPT: Control power transformer.

B. MCC: Motor-control center.

C. MCCB: Molded-case circuit breaker.

D. MCP: Motor-circuit protector.

E. OCPD: Overcurrent protective device.

F. PT: Potential transformer.

G. SPD: Surge protective device.

H. SCR: Silicon-controlled rectifier.

I. VFC: Variable-frequency controller.

J. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 Action Submittals

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for MCCs.

2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories for each cell of the MCC.

B. Shop Drawings: For each MCC, manufacturer's approval and production drawings as defined in UL 845. In addition to requirements specified in UL 845, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:

    a. Each installed unit's type and details.

    b. Factory-installed devices.

    c. Enclosure types and details.

    d. Nameplate legends.

    e. Short-circuit current (withstand) rating of complete MCC, and for bus structure and each unit.

    f. Features, characteristics, ratings, and factory settings of each installed controller and feeder device, and installed devices.

    g. Specified optional features and accessories.

2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring for each installed controller.

3. Nameplate legends.

4. Vertical and horizontal bus capacities.

5. Features, characteristics, ratings, and factory settings of each installed unit.

1.4 Informational Submittals

A. Standard Drawings: For each MCC, as defined in UL 845.

B. Production Drawings: For each MCC, as defined in UL 845.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around MCCs where pipe and ducts are prohibited. Show MCC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Product Certificates: For each MCC.

E. Source quality-control reports.

F. Field quality-control reports.

G. Load-Current and Overload Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

H. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

I. Sample Warranty: For special warranty.

1.5 Closeout Submittals

A. Operation and Maintenance Data: For MCCs, all installed devices, and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 78 23 - Operation and Maintenance Data, include the following:

2. Manufacturer's Record Drawings: As defined in UL 845. In addition to requirements specified in UL 845, include field modifications and field-assigned wiring identification incorporated during construction by manufacturer, Contractor, or both.

3. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.

4. Manufacturer's written instructions for setting field-adjustable overload relays.

5. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage, solid-state controllers.

6. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.

7. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

1.6 Quality Assurance

A. Source Limitations: Obtain MCCs and controllers of a single type from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 and marked for intended use.

C. UL Compliance: MCCs shall comply with UL 845 and shall be listed and labeled by a qualified testing agency.

1.7 Delivery, Storage, and Handling

A. Deliver MCCs in shipping splits of lengths that can be moved past obstructions in delivery paths.

B. Handle MCCs according to the following:

1. NECA 402, "Recommended Practice for Installing and Maintaining Motor Control Centers."

2. NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600 Volts."

C. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside MCCs; connect factory-installed space heaters to temporary electrical service.

Part 2 Products

2.1 Manufacturers

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

1. Schneider Electric.

2.2 System Description

A. NEMA Compliance: Fabricate and label MCCs to comply with NEMA ICS 18.

B. Ambient Environment Ratings:

1. Ambient Temperature Rating: Not less than 0 deg F and not exceeding 104 deg F, with an average value not exceeding 95 deg F over a 24-hour period.

2. Ambient Storage Temperature Rating: Not less than minus 4 deg F and not exceeding 140 deg F

3. Humidity Rating: Less than 95 percent (noncondensing).

4. Altitude Rating: Not exceeding 6600 feet, or 3300 feet if MCC includes solid-state devices.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 Performance Requirements

A. Capacities and Characteristics:

1. MCC Enclosure and Assembly:

   a. Nominal System Voltage: 277/480-V ac.

   b. Service Equipment Rated: Yes.

   c. Enclosure: NEMA 250, Type 1G unless otherwise indicated.

2. Integrated Short-Circuit Rating for MCC:

   a. Fully rated; 65 kA.

3. Integrated Short-Circuit Rating for Each Unit:

   a. Combination series rated; 65 kA.

4. Wiring Class: I-B.

5. Bus:

   a. Horizontal Bus: As indicated.

   b. Neutral Bus: 50 percent in main compartment of service MCC only.

6. Main Disconnect Device:

   a. Main Disconnect: MCCB, UL 489, three pole, Amperes as indicated. Manually operated, electrically tripped.

   b. SPD: UL 1449, Type 1.

   c. Optional Features: Digital power meter.

7. Magnetic Controllers: As indicated.

8. Reduced-Voltage Solid-State Controllers: As indicated.

9. VFCs: As indicated.

10. Controller-Mounted Auxiliary Devices:

   a. Push Buttons and Selector Switches: Heavy-duty, oiltight type.

   b. Feeder Tap Units: Main Disconnect: MCCB, UL 489, three pole, A. Manually operated, electrically tripped as indicated.

2.4 Motor Control Center Enclosures

A. Indoor Enclosures: Freestanding steel cabinets unless otherwise indicated. NEMA 250, Type 12 unless otherwise indicated to comply with environmental conditions at installed location.

B. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.

2. Space-Heater Power Source: Transformer, factory installed in MCC.

C. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

2.5 Assembly

A. Structure:

1. Comply with UL requirements for service entrance equipment.

2. Units up to and including Size 3 shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.

3. Units in Type B and Type C MCCs shall have pull-apart terminal strips for external control connections.

4. Pull Boxes:

a. Include provisions for ventilation to maintain temperature in pull box within same limits as the MCC.

b. Covers: Removable covers forming top, front, and sides.

c. Insulated bottom of fire-resistive material with separate holes for cable drops into MCC.

d. Cable Supports: Arranged to facilitate cabling and adequate to support cables, including supports for future cables.

e. When equipped with barriers, supply with access to check bus bolt tightness.

B. Compartments: Modular; individual lift-off doors with concealed hinges and quick-captive screw fasteners.

1. Interlock compartment door to require that the disconnecting means is "off" before door can be opened or closed, except by operating a concealed release device.

2. Compartment construction shall allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC.

3. The same-size compartments shall be interchangeable to allow rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

C. Bus Transition and Incoming Pull Sections: Included and aligned with the structure of the MCC.

D. Owner's Metering Compartment: A separate customer metering compartment and section with front hinged door, metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include PTs having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

E. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC; same-size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

F. Wiring Spaces:

1. Vertical wireways in each vertical section for vertical wiring to each unit compartment; supports to hold wiring in place.

2. Horizontal wireways in top of each vertical section for horizontal wiring between vertical sections; supports to hold wiring in place.

G. Provisions for Future:

1. Compartments marked "future" shall be bused, wired, and equipped with guide rails or equivalent, and ready for insertion of drawout units.

2. Compartments marked "spare" shall include provisions for connection to the vertical bus.

H. Integrated Short-Circuit Rating:

1. Short-Circuit Current Rating for Each Unit: Combination series rated; 65 kA.

2. Short-Circuit Current Rating of MCC: Fully rated with its main overcurrent device; 65 kA.

I. Control Power:

1. 120-V ac; obtained from CPT integral with controller; with primary and secondary fuses. The CPT shall be of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

a. CPT Spare Capacity: 200 VA.

J. Factory-Installed Wiring: Factory installed, with bundling, lacing, and protection included. Use flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

1. Wiring Class: NEMA ICS 18, Class I, Type B, for starters larger than Size 3 Type B-T, for starters Size 3 and smaller.

2. Control and Load Wiring: Factory installed, with bundling, lacing, and protection included. Use flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

K. Bus:

1. Main Horizontal and Equipment Ground Buses: Uniform capacity for entire length of MCC's main and vertical sections. Provide for future extensions from both ends.

2. Vertical Phase and Equipment Ground Buses: Uniform capacity for entire usable height of vertical sections, except for sections incorporating single units.

3. Bus Material: Hard-drawn copper of 98 percent minimum conductivity or silver-plated alloy, with mechanical connectors for outgoing conductors.

4. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for ground conductors, minimum size 1/4-by-2 inches. Equip with mechanical connectors for outgoing conductors.

5. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch copper bus, arranged to connect neutral bus to ground bus.

6. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Insulation temperature rating shall not be less than 105 deg C.

2.6 Main Disconnect and Overcurrent Protective Device(s)

A. MCCB (up to 2500 A): Fixed mounted, manually operated air-circuit breaker. Comply with UL 489.

1. MCCB shall have quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, its position shall be shown by the position of the handle, and manual push-to-trip push button.

    a. One test kit to test each trip function.

    b. Battery backup for informational displays after automatic trip, with battery status indicator.

2. Switch operator power shall be from control power specified in "Assembly" Article.

B. Surge Suppression: Factory installed as an integral part of the incoming feeder, complying with UL 1449, SPD Type 1.

2.7 Magnetic Controllers

A. Controller Units: Combination controllers.

B. Disconnects:

1. MCP:

    a. UL 489, with interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

    b. Lockable Handle: For three padlocks and interlocks with cover in closed position.

    c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.

    d. NO alarm contact that operates only when MCP has tripped.

    e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

C. Controllers: Comply with UL 508.

1. Full-Voltage Magnetic Controllers: Electrically held, full voltage, NEMA ICS 2, general purpose, Class A.

    a. Classification: Non-reversing and reversing as indicated.

D. Overload Relays:

1. Solid-State Overload Relays:

    a. Switch or dial selectable for motor-running overload protection.

b. Sensors in each phase.

c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

d. UL 1053 Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

2. NO isolated overload alarm contact.

3. External overload reset push button.

2.8 Reduced-Voltage Solid-State Controllers

A. Controller Units: An integrated unit with disconnects, power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relays. Comply with UL 508.

1. Suitable for use with NEMA MG 1 Design B, polyphase induction motors.

B. Disconnects:

a. UL 489, with interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

b. Lockable Handle: For three padlocks and interlocks with cover in closed position.

c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.

d. NO alarm contact that operates only when MCP has tripped.

e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

C. Configuration: Severe duty; nonreversible.

D. Starting Mode: Voltage ramping and current limit; field selectable.

E. Stopping Mode: Coast to stop and adjustable braking; field selectable.

F. Bypass Contactor: Shall operate automatically to bypass the SCRs when the motor has reached rated speed and full voltage is applied to motor. Solid-state controller protective features shall remain active when the bypass relay is in the bypass mode.

1. Bypass Contactor: Manufacturer's standard product.

2. Bypass Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating.

G. Acceleration Control: Adjustable, using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds minimum.

H. SCR Bridge: At least two SCRs per phase, for stable and smooth acceleration without external feedback from the motor or driven equipment.

I. Keypad: Unit door mounted, front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:

1. Adjusting motor full-load amperes, as a percentage of the controller's rating.

2. Adjusting current limitation on starting, as a percentage of the motor full-load current rating.

3. Adjusting linear acceleration and deceleration ramps, in seconds.

4. Setting initial torque, as a percentage of the nominal motor torque.

5. Adjusting torque limit, as a percentage of the nominal motor torque.

6. Adjusting maximum start time, in seconds.

7. Adjusting voltage boost, as a percentage of the nominal supply voltage.

8. Selecting stopping mode and adjusting parameters.

9. Selecting motor thermal-overload protection class between 5 and 30.

10. Activating and deactivating protection modes.

11. Selecting or activating communications modes.

J. Digital Display: Front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:

1. Controller Condition: Ready, starting, running, stopping.

2. Motor Condition: Amperes, voltage, power factor, power, and thermal state.

3. Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.

K. Controller Diagnostics and Protection:

1. Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics and providing controller overtemperature and motor overload alarm and trip; settings selectable via the keypad.

2. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency excursions to over- or under-normal.

L. Remote Output Features:

1. All outputs prewired to terminal blocks.

2. Form C status contacts that change state when controller is running.

3. Form C alarm contacts that change state when a fault condition occurs.

M. Overload Relays:

1. Solid-State Overload Relays:

a. Switch or dial selectable for motor-running overload protection.

b. Sensors in each phase.

c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

d. UL 1053, Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

2.9 VFC

A. Controller Units: Refer to Section 26 29 23 - Variable-Frequency Motor Controllers. (VFC units will be in separate stand-alone and dead front VFD cabinet enclosures.) Combination controllers, consisting of variable-frequency power converter that is factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged for self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency. Comply with NEMA ICS 7, NEMA ICS 61800-2, UL 508C, and UL 508E.

B. Disconnects:

1. MCCB:

a. UL 489, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.

b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

c. Lockable Handle: For three padlocks and interlocks with cover in closed position.

d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.

e. NO alarm contact that operates only when MCCB has tripped.

2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.

3. Auxiliary Contacts: NO, arranged to activate before switch blades open.

4. NO alarm contact that operates only when circuit breaker has tripped.

2.10 Controller-Mounted Auxiliary Devices

A. Control-Circuit and Pilot Devices: Factory installed in controller enclosure cover unless otherwise indicated. Comply with NEMA ICS 5.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oiltight type.

a. Push Buttons: Shielded types; momentary contact unless otherwise indicated.

b. Pilot Lights: LED type.

c. Selector Switches: Rotary type.

B. Elapsed-Time Meters: Heavy duty with digital readout in hours; non-resettable.

C. Auxiliary Dry Contacts: Reversible NC/NO (2 sets).

D. Control Relays:

1. Time Delay: Auxiliary and adjustable solid-state time-delay relays.

2.11 Measurement and Control Devices

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. PTs: IEEE C57.13; 120 V, 60 Hz, double secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.

2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; bar or window type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Listed or recognized by a nationally recognized testing laboratory.

2. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.

3. Switch-selectable digital display of the following values with the indicated maximum accuracy tolerances:

a. Phase Currents, Each Phase: Plus or minus 1 percent.

b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.

c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.

d. Three-Phase Real Power (Megawatts): Plus or minus 2 percent.

e. Three-Phase Reactive Power (Megavars): Plus or minus 2 percent.

f. Power Factor: Plus or minus 2 percent.

g. Frequency: Plus or minus 0.5 percent.

h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.

4. Mounting: Display and control unit flush or semi flush mounted in instrument compartment door.

C. Control Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

2.12 Feeder Tap Units

A. MCCBs (up to 1200 A): Fixed mounted, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger. Comply with UL 489, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

1. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

2.13 Source Quality Control

A. MCC Testing: Test and inspect MCCs according to requirements in NEMA ICS 18.

B. VFC Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.

2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

C. MCCs will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

Part 3 Execution

3.1 Examination

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

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

3.2 Installation

A. NEMA Industrial Control and Systems Standards: Comply with parts of NEMA ICS 2.3 for installation and startup of MCCs.

B. Floor Mounting: Install MCCs on 4-inch nominal-thickness concrete base.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Comply with NECA 1.

3.3 Identification

A. Comply with requirements in Section 26 05 53 - Identification for Electrical Systems for identification of MCC, MCC components, and control wiring.

1. Identify field-installed conductors, interconnecting wiring, and components.

2. Install required warning signs.

3. Label MCC and each cubicle with engraved nameplate.

4. Label each enclosure-mounted control and pilot device.

5. Mark up a set of manufacturer's connection wiring diagrams with field-assigned wiring identifications and return to manufacturer for inclusion in Record Drawings.

3.4 Control Wiring Installation

A. Bundle, train, and support wiring in enclosures.

B. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.

2. Connect selector switches within enclosed controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 Connections

A. Comply with requirements for installation of conduit in Section 26 05 33 - Raceways and Boxes for Electrical Systems. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Comply with requirements in Section 26 05 26 - Grounding and Bonding for Electrical Systems.

3.6 Field Quality Control

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

4. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multipole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.

b. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Submit calibration record for device.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

6. Mark up a set of manufacturer's drawings with all field modifications incorporated during construction and return to manufacturer for inclusion in Record Drawings.

E. MCCs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 Startup Service

A. Perform startup service.

1. Complete installation and startup checks according to NETA Acceptance Testing Specification and manufacturer's written instructions.

3.8 Adjusting

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload relay pickup and trip ranges.

B. Adjust overload relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer before increasing settings.

D. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage, solid-state controllers.

E. Program microprocessors in VFCs for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

3.9 Demonstration

A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers, and to use and reprogram microprocessor-based, reduced-voltage, solid-state controllers.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Extra hard use specification-grade receptacles, 125 V, 20 A.
2. GFCI receptacles, 125 V, 20 A.
3. SPD receptacles, 125 V, 20 A.
4. Corrosion resistant receptacles, 125 V, 20 A.
5. Hazardous (classified) location receptacles.
6. Twist-locking receptacles.
7. Pendant cord-connector devices.
8. Cord and plug sets.
9. Toggle switches, 120/277 V, 20 A.
10. Occupancy sensors.
11. Digital timer light switches.
12. Residential devices.
13. Wall plates.
14. Prefabricated multioutlet assemblies.

1.2 Definitions

A. AFCI: Arc-fault circuit interrupter.

B. BAS: Building automation system.

C. EMI: Electromagnetic interference.

D. GFCI: Ground-fault circuit interrupter.

E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

F. RFI: Radio-frequency interference.

G. SPD: Surge protective device.

1.3 Action Submittals

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.4 Informational Submittals

A. Field quality-control reports.

1.5 Closeout Submittals

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

Part 2 Products

2.1 General Wiring-Device Requirements

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Comply with NFPA 70.

C. RoHS compliant.

D. Comply with NEMA WD 1.

E. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.

2. Devices shall comply with requirements in this Section.

F. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.

2. Cord and Plug Sets: Match equipment requirements.

G. Device Color:

1. Wiring Devices Connected to Normal Power System: Gray unless otherwise indicated or required by NFPA 70 or device listing.

2. Corrosion Resistant Wiring Devices: Yellow.

3. SPD Devices: Blue.

4. Isolated-Ground Receptacles: As specified above, with orange triangle on face.

H. Wall Plate Color: For plastic covers, match device color.

I. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 Extra Hard Use Specification-Grade Receptacles, 125 V, 20 A

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

1. Eaton (Arrow Hart).

2. Hubbell Incorporated; Wiring Device-Kellems.

3. Leviton Manufacturing Co., Inc.

4. Pass & Seymour/Legrand (Pass & Seymour).

5. Schneider Electric.

B. Duplex Receptacles, 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding.

2. Configuration: NEMA WD 6, Configuration 5-20R.

3. Standards: Comply with UL 498 and FS W-C-596.

C. Isolated-Ground Duplex Receptacles, 125 V, 20 A:

1. Description: Straight blade; equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts. Two pole, three wire, and self-grounding.

2. Configuration: NEMA WD 6, Configuration 5-20R.

3. Standards: Comply with UL 498 and FS W-C-596.

D. Tamper-Resistant Duplex Receptacles, 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.

2. Configuration: NEMA WD 6, Configuration 5-20R.

3. Standards: Comply with UL 498 and FS W-C-596.

4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

E. Corrosion-Resistant Duplex Receptacle, 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.

2. Configuration: NEMA WD 6, Configuration 5-20R.

3. Standards: Comply with UL 498.

4. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

2.3 GFCI Receptacles, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A:

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.

2. Configuration: NEMA WD 6, Configuration 5-20R.

3. Type: Non-feed through.

4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

2.4 SPD Receptacles, 125 V, 20 A

A. Duplex SPD Receptacles, 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding. Integral SPD in line to ground, line to neutral, and neutral to ground. LED indicator light.

2. SPD Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 V and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.

3. Active SPD Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."

4. Configuration: NEMA WD 6, Configuration 5-20R.

5. Standards: Comply with NEMA WD 1, UL 498, UL 1449, and FS W-C-596.

2.5 Hazardous (Classified) Location Receptacles

A. Hazardous (Classified) Locations Receptacles:

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

   a. Eaton (Arrow Hart).

   b. EGS/Appleton Electric.

   c. Killark.

   d. Schneider Electric.

2. Description: Pin and sleeve receptacle with matching connector.

3. Class I.

   a. Division: 1 or 2 per area classification diagrams.

2.6 Twist-Locking Receptacles

A. Twist-Lock, Single Receptacles, configurations as noted:

1. Configuration: NEMA WD 6, Configuration as indicated.

2. Standards: Comply with UL 498.

3. Provide corrosion resistant device where indicated.

2.7 Pendant Cord-Connector Devices

A. Description: Matching, locking-type plug and receptacle body connector, heavy-duty grade.

B. Configuration: NEMA WD 6, Configurations as indicated.

C. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.

D. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

E. Standards: Comply with FS W-C-596.

2.8 Cord and Plug Sets

A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.

B. Cord: Rubber-insulated, stranded-copper conductors, with Type SO jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.9 Toggle Switches, 120/277 V, 20 A

A. Antimicrobial, Single-Pole Switches, 120/277 V, 20 A:

1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.

2. Standards: Comply with UL 20 and FS W-S-896.

B. Two-Pole Switches, 120/277 V, 20 A.

C. Antimicrobial, Double-Pole Switches, 120/277 V, 20 A:

1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.

2. Standards: Comply with UL 20 and FS W-S-896.

D. Antimicrobial, Three-Way Switches, 120/277 V, 20 A:

1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.

2. Standards: Comply with UL 20 and FS W-S-896.

E. Lighted Single-Pole Switches, 120/277 V, 20 A:

1. Description: Handle illuminated when switch is off.

2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

F. Key-Operated, Single-Pole Switches, 120/277 V, 20 A:

1. Description: Factory-supplied key in lieu of switch handle.

2. Standards: Comply with UL 20 and FS W-S-896.

G. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches, 120/277 V, 20 A:

1. Description: For use with mechanically held lighting contactors.

2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

2.10 Occupancy Sensors

A. Wall Sensor Light Switch, Passive Infrared:

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

a. Cooper Industries.

b. Hubbell Premise Wiring.

c. Leviton Manufacturing Co., Inc.

d. Pass & Seymour/Legrand (Pass & Seymour).

e. Watt Stopper.

f. Sensor Switch.

2. Description: Switchbox-mounted, combination, lighting-control sensor and conventional switch lighting-control unit using passive infrared technology.

3. Standards: Comply with UL 20.

4. Connections: Hard wired.

5. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.

6. Adjustable time delay of five to 30 minutes.

7. Able to be locked to Manual-On mode.

8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc.

2.11 Timer Light Switch

A. Digital Timer Light Switch:

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

a. Eaton (Arrow Hart).

b. Hubbell Incorporated; Wiring Device-Kellems.

c. Leviton Manufacturing Co., Inc.

d. Watt Stopper.

e. Sensor Switch.

2. Description: Switchbox-mounted, combination digital timer and conventional switch lighting-control unit, with backlit digital display, with selectable time interval from 10 to 60-minutes.

3. Standards: Comply with UL 20.

4. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.

2.12 Wall Plates

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.

2. Material for Finished Spaces: 0.035-inch- thick, satin-finished, Type 302 stainless steel.

3. Material for Unfinished Spaces: Galvanized steel.

4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover and listed and labeled for use in wet and damp locations.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

Part 3 Execution

3.1 Installation

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.

3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.

4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.

2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.

3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.

4. Existing Conductors:

   a. Cut back and pigtail or replace all damaged conductors.

   b. Straighten conductors that remain and remove corrosion and foreign matter.

   c. Pig tailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.

2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.

4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.

5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.

6. Use a torque screwdriver when a torque is recommended or required by manufacturer.

7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.

8. Tighten unused terminal screws on the device.

9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

3.2 GFCI Receptacles

A. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required.

3.3 Identification

A. Comply with Section 26 05 53 - Identification for Electrical Systems.

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 Field Quality Control

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.

2. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.

2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.

3. Ground Impedance: Values of up to 2 ohms are acceptable.

4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.

5. Using the test plug, verify that the device and its outlet box are securely mounted.

6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

E. Wiring device will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:

    a. Control circuits.

    b. Motor-control centers.

    c. Panelboards.

    d. Switchboards.

    e. Enclosed controllers.

    f. Enclosed switches.

2. Spare-fuse cabinets (where indicated).

1.2 Action Submittals

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

    a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.

    b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.

3. Current-limitation curves for fuses with current-limiting characteristics.

4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software and in PDF format.

5. Coordination charts and tables and related data.

6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.3 Maintenance Material Submittals

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

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.4 Field Conditions

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

Part 2 Products

2.1 Manufacturers

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

1. Cooper Bussmann.

2. Edison; a brand of Cooper Bussmann.

3. Littelfuse, Inc.

4. Goulds.

5. Schneider Electric.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 Cartridge Fuses

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 250 and 600-V, zero- to 600-A rating, 200 kAIC, time delay.

2. Type RK-5: 250 and 600-V, zero- to 600-A rating, 200 kAIC, time delay.

3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting.

4. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.

5. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 Spare-Fuse Cabinet

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: 24”H x 20”W x 6”D minimum.

2. Finish: Gray, baked enamel.

3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.

4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

Part 3 Execution

3.1 Examination

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.2 Fuse Applications

A. Cartridge Fuses:

1. Service Entrance: Class L, time delay and Class RK1, time delay based upon size.

2. Feeders: Class L, time delay and Class RK1, time delay based upon size.

3. Motor Branch Circuits: Class RK5, time delay.

4. Power Electronics Circuits: Class J, high speed.

5. Control Transformer Circuits: Class CC, time delay, control transformer duty.

6. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 Installation

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Owner’s Representative.

3.4 Identification

A. Install labels complying with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Fusible switches.
2. Non-fusible switches.
3. Receptacle switches.
4. Molded-case circuit breakers (MCCBs).
5. Enclosures.

1.2 Definitions

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.3 Action Submittals

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes. All enclosures and panels will be electrically dead front.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of NRTL listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.4 Informational Submittals

A. Field quality-control reports.

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 Closeout Submittals

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.6 Quality Assurance

A. Testing Agency Qualifications: Refer to Division 26 Section “Electrical Testing.”

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NFPA 70.

1.7 Project Conditions

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.

2. Altitude: Not exceeding 6600 feet.

1.8 Coordination

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

Part 2 Products

2.1 Fusible Switches

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 240 and 600-V ac (match circuit voltage), 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Double Throw, 240 and 600-V ac (match circuit voltage), 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Accessories:

1. Equipment Ground Kit (ALL Units): Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit (Where Indicated): Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.

4. Auxiliary Contact Kit (ALL Motor Circuits): Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.

5. Hookstick Handle (All): Allows use of a hookstick to operate the handle.

6. Lugs: Mechanical type, suitable for number, size, and conductor material.

7. Service-Rated Switches (Where Noted): Labeled for use as service equipment.

8. Visible break polycarbonate view window (ALL).

2.2 Non-fusible Switches

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 240 and 600-V ac (match circuit voltage), 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Double Throw, 240 and 600-V ac (match circuit voltage), 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Accessories:

1. Equipment Ground Kit (ALL Units): Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit (Where Indicated): Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

3. Auxiliary Contact Kit (ALL Motor Circuits): Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.

4. Hookstick Handle (All): Allows use of a hookstick to operate the handle.

5. Lugs: Mechanical type, suitable for number, size, and conductor material.

6. Service-Rated Switches (Where Noted): Labeled for use as service equipment.

7. Visible break polycarbonate view window (ALL).

2.3 Receptacle Switches

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Square D; a brand of Schneider Electric.

4. Crouse-Hinds.

5. Appleton Electric.

B. Type HD, Heavy-Duty, Single-Throw Fusible Switch: 600-V ac, 60 A; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to accommodate specified fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

C. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.

D. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

2.4 Molded-Case Circuit Breakers

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Square D; a brand of Schneider Electric.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents. 10kA minimum for 240 VAC and lower systems and 65kA minimum for 480V systems unless otherwise indicated.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 100 A and larger.

D. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip and I2t response.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I2t response.

E. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

F. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

G. Features and Accessories where indicated:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

2.5 Enclosures

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 4X.
3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4X.
4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

5. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7.

Part 3 Execution

3.1 Examination

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 Installation

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in fusible devices.

D. Comply with NECA 1.

3.3 Identification

A. Comply with requirements in Section 26 05 53 - Identification for Electrical Systems.

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 Field Quality Control

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

B. Perform tests and inspections.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Perform the following infrared scan tests and inspections and prepare reports:

   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.

   b. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 Adjusting

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73 - Overcurrent Protective Device Coordination Study.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Manual motor controllers.
2. Enclosed full-voltage magnetic motor controllers.
3. Combination full-voltage magnetic motor controllers.
4. Enclosures.
5. Accessories.
6. Identification.

1.2 Definitions

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. NC: Normally closed.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SCPD: Short-circuit protective device.

1.3 Action Submittals

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type of magnetic controller.

1. Include plans, elevations, sections, and mounting details.
2. Indicate dimensions, weights, required clearances, and location and size of each field connection.

3. Wire Termination Diagrams and Schedules: Include diagrams for signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.

4. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

C. Product Schedule: List the following for each enclosed controller:

1. Each installed magnetic controller type.

2. NRTL listing.

3. Factory-installed accessories.

4. Nameplate legends.

5. SCCR of integrated unit.

6. For each combination magnetic controller include features, characteristics, ratings, and factory setting of the SCPD and OCPD.

   a. Listing document proving Type 2 coordination.

7. For each series-rated combination state the listed integrated short-circuit current (withstand) rating of SCPD and OCPDs by an NRTL acceptable to authorities having jurisdiction.

1.4 Informational Submittals

A. Field quality-control reports.

1.5 Closeout Submittals

A. Operation and Maintenance Data: For magnetic controllers to include in operation and maintenance manuals.

1. In addition to items specified in Section 01 78 23 - Operation and Maintenance Data, include the following:

   a. Routine maintenance requirements for magnetic controllers and installed components.

   b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.

c. Manufacturer's written instructions for setting field-adjustable overload relays.

d. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 Delivery, Storage, and Handling

A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 50 W.

1.7 Field Conditions

A. Ambient Environment Ratings: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than 23 deg F and not exceeding 122 deg F.

2. Altitude: Not exceeding 6600 feet for electromagnetic and manual devices.

3. The effect of solar radiation is significant.

Part 2 Products

2.1 Performance Requirements

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.

2.2 Manual Motor Controllers

A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

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

a. General Electric Company.

b. Rockwell Automation, Inc.

c. Square D; by Schneider Electric.

d. Eaton.

2. Standard: Comply with NEMA ICS 2, general purpose, Class A.

3. Configuration: Non-reversing.

4. Surface mounting.

B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

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

a. General Electric Company.

b. Rockwell Automation, Inc.

c. Square D; by Schneider Electric.

d. Eaton.

2. Configuration: Non-reversing.

3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 20 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.

2.3 Enclosed Full-Voltage Magnetic Motor Controllers

A. Description: Across-the-line start, electrically held, for nominal system voltage of 600-V ac and less.

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

1. General Electric Company.

2. Rockwell Automation, Inc.

3. Siemens Industry, Inc., Energy Management Division.

4. Square D; by Schneider Electric.

5. Eaton.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration: As scheduled.

E. Contactor Coils: Pressure-encapsulated type with coil transient suppressors when indicated.

1. Operating Voltage: 120 VAC unless indicated.

F. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.

a. Spare CPT Capacity as Indicated on Drawings: 100 VA minimum.

G. Overload Relays:

1. Solid-State Overload Relay:

a. Switch or dial selectable for motor-running overload protection.

b. Sensors in each phase.

c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

d. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.

2.4 Combination Full-Voltage Magnetic Motor Controller

A. Description: Factory-assembled, combination full-voltage magnetic motor controller consisting of the controller described above, indicated disconnecting means, SCPD and OCPD, in a single enclosure.

B. Standard: Comply with NEMA ICS 2, general purpose, Class A.

C. MCCB Disconnecting Means:

1. UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse-time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.

2. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

3. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

D. Withstand ratings: The combination assembly shall have a minimum fault withstand rating of 42Ka or as specified on drawings.

2.5 Enclosures

A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.

B. All enclosures and panels to be electrically dead front.

C. The construction of the enclosures shall comply with NEMA ICS 6.

D. Controllers in hazardous (classified) locations shall comply with UL 1203.

2.6 Accessories

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, except as needed to match enclosure type. Heavy-duty or oil-tight where indicated in the controller schedule.

a. Push Buttons: As indicated in the controller schedule.

b. Pilot Lights: As indicated in the controller schedule.

2. Elapsed Time Meters: Heavy duty with digital readout in hours; non-resettable.

B. Breather assemblies, to maintain interior pressure and release condensation in Type 4X and Type 7 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

C. Space heaters, with NC auxiliary contacts, to mitigate condensation in Type 4X and Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

D. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

2.7 Identification

A. Controller Nameplates: Laminated acrylic or melamine plastic signs, as described in Section 26 05 53 - Identification for Electrical Systems, for each compartment, mounted with corrosion-resistant screws.

B. Arc-Flash Warning Labels:

1. Comply with requirements in Section 26 05 74 – Overcurrent Protective Device Arc-Flash Study. Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.

a. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1) Location designation.

2) Nominal voltage.

3) Flash protection boundary.

4) Hazard risk category.

5) Incident energy.

6) Working distance.

7) Engineering report number, revision number, and issue date.

b. Labels shall be machine printed, with no field-applied markings.

Part 3 Execution

3.1 Examination

A. Examine areas and space conditions for compliance with requirements for motor controllers, their relationship with the motors, and other conditions affecting performance of the Work.

3.2 Installation

A. Comply with NECA 1.

B. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 26 05 29 - Hangers and Supports for Electrical Systems unless otherwise indicated.

C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.

3.3 Identification

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.

3.4 Field Quality Control

A. Perform tests and inspections.

B. Tests and Inspections:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.

2. Visual and Mechanical Inspection:

a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, and grounding.

d. Verify the unit is clean.

e. Inspect contactors:

1) Verify mechanical operation.

2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.

f. Motor-Running Protection:

1) Verify overload element rating is correct for its application.

2) If motor-running protection is provided by fuses, verify correct fuse rating.

g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter. Compare bolted connection resistance values with values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

3. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Insulation-resistance values shall be according to manufacturer's published data or NETA ATS Table 100.1. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than those of this table or manufacturer's recommendations shall be investigated and corrected.

b. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

c. Test motor protection devices according to manufacturer's published data.

d. Test circuit breakers as follows:

1) Operate the circuit breaker to ensure smooth operation.

2) For adjustable circuit breakers, adjust protective device settings according to the coordination study. Comply with coordination study recommendations.

e. Perform operational tests by initiating control devices.

4. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove all necessary covers prior to the inspection.

a. Comply with the recommendations of NFPA 70B, "Testing and Test Methods" Chapter, "Infrared Inspection" Article.

b. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of each motor controller.

c. Report of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used, and lists the following results:

1) Description of equipment to be tested.

2) Discrepancies.

3) Temperature difference between the area of concern and the reference area.

4) Probable cause of temperature difference.

5) Areas inspected. Identify inaccessible and unobservable areas and equipment.

6) Load conditions at time of inspection.

7) Photographs and thermograms of the deficient area.

8) Recommended action.

d. Equipment: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1°C at 30°C. The equipment shall detect emitted radiation and convert detected radiation to a visual signal.

e. Act on inspection results and recommended action, and considering the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

C. Motor controller will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 System Function Tests

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.

2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.

3. Verify the correct operation of sensing devices, alarms, and indicating devices.

B. Motor controller will be considered defective if it does not pass the system function tests and inspections.

C. Prepare test and inspection reports.

3.6 Demonstration

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

END OF SECTION

Part 1 General

1.1 Summary

A. Section includes preassembled, combination VFDs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.2 Definitions

A. CE: Conformite Europeene (European Compliance).

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. LED: Light-emitting diode.

F. NC: Normally closed.

G. NO: Normally open.

H. OCPD: Overcurrent protective device.

I. PID: Control action, proportional plus integral plus derivative.

J. RFI: Radio-frequency interference.

K. VFD: Variable-frequency motor drive

1.3 Action Submittals

A. Product Data: For each type and rating of VFD indicated.

1. Include dimensions and finishes for VFDs.

2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFD indicated.

1. Include mounting and attachment details.

2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Include diagrams for power, signal, and control wiring.

1.4 Informational Submittals

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which, the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Required working clearances and required area above and around VFDs.

2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.

3. Show support locations, type of support, and weight on each support.

4. Indicate field measurements.

B. Product Certificates: For each VFD from manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

E. Sample Warranty: For special warranty.

1.5 Closeout Submittals

A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 78 23 - Operation and Maintenance Data, include the following:

a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.

b. Manufacturer's written instructions for setting field-adjustable overload relays.

c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.

d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

e. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 Delivery, Storage, and Handling

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFDs, including clearances between VFDs, and adjacent surfaces and other items.

1.7 Warranty

A. Special Warranty: Manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.

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

Part 2 Products

2.1 Manufacturers

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Danfoss, Schneider Electric, Yaskawa or approved equal.

2.2 System Description

A. General Requirements for VFDs:

1. VFDs will be supplied in approved stand-alone rated cabinets that are electrically dead front.

2. VFDs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A and UL 508C as applicable for each condition of installation.

B. Application: Constant torque on all applications except centrifugal pumps and variable torque on centrifugal pumps.

C. VFD Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General-Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."

2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."

3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 1 to 60 Hz, with voltage proportional to frequency throughout voltage range for variable torque applications and 1-66 Hz minimum with torque constant as speed changes for all other applications; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFD input voltage rating.

2. Input AC Voltage Unbalance: Not exceeding 5 percent.

3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.

4. Minimum Efficiency: 96 percent at 60 Hz, full load.

5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.

6. Minimum Short-Circuit Current (Withstand) Rating: 65 kA.

7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 122 deg F.

8. Humidity Rating: Less than 95 percent (noncondensing).

9. Altitude Rating: Not exceeding 3300 feet.

10. Vibration Withstand: Comply with NEMA ICS 61800-2.

11. Overload Capability: 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.

13. Speed Regulation: Plus or minus 5 percent.

14. Output Carrier Frequency: Selectable; 0.5 to 2.5 kHz.

15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

H. Isolated Control Interface: Allows VFDs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.

I. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.

2. Maximum Speed: 80 to 100 percent of maximum rpm.

3. Acceleration: 0.1 to 999.9 seconds.

4. Deceleration: 0.1 to 999.9 seconds.

5. Current Limit: 30 to minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFD, complying with UL 1449 SPD, Type 1 or Type 2.

2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.

3. Under- and overvoltage trips.

4. Inverter overcurrent trips.

5. VFD and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor-overload alarm and trip; settings selectable via the keypad.

6. Critical frequency rejection, with three selectable, adjustable deadbands.

7. Instantaneous line-to-line and line-to-ground overcurrent trips.

8. Loss-of-phase protection.

9. Reverse-phase protection.

10. Short-circuit protection.

11. Motor-overtemperature fault.

K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

M. Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fallback based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Integral Input Disconnecting Means and OCPD: UL 489, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.

2. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.

3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.

4. NO alarm contact that operates only when circuit breaker has tripped.

2.3 Controls and Indication

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Ready (Green)

2. Running (Red)

3. Bypass Mode (Blue)

4. Fault (Amber).

5. MPR Fault (Amber)

B. Panel-Mounted switches and pushbuttons:

1. HOA Switch (Hand-Off-Auto)

2. Normal/Bypass Mode Position Switch

3. Speed Control Potentiometer. Provide speed potentiometer on the drive door in addition to the HIM up/down arrows.

C. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.

2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

a. Control Authority: Supports at least four conditions: Off, local manual control at VFC and automatic control through a remote source.

D. Historical Logging Information and Displays:

1. Real-time clock with current time and date.

2. Running log of total power versus time.

3. Total run time.

4. Fault log, maintaining last four faults with time and date stamp for each.

E. Indicating Devices: Digital display mounted flush in VFD door and connected to display VFD parameters including, but not limited to:

1. Output frequency (Hz).

2. Motor speed (rpm).

3. Motor status (running, stop, fault).

4. Motor current (amperes).

5. Motor torque (percent).

6. Fault or alarming status (code).

7. PID feedback signal (percent).

8. DC-link voltage (V dc).

9. Set point frequency (Hz).

10. Motor output voltage (V ac).

F. Control Signal Interfaces:

1. Electric Input Signal Interface:

a. A minimum of two programmable analog inputs: 4- to 20-mA dc (scalable).

b. A minimum of eight multifunction programmable digital inputs (dry contact inputs).

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the SCADA system or equipment control systems:

a. 4- to 20-mA dc.

b. Modbus connection

3. Output Signal Interface: A minimum of two programmable analog output signal(s) (4- to 20-mA dc operator-selectable), which can be configured for any of the following:

a. Output frequency (Hz).

b. Output current (load).

c. DC-link voltage (V dc).

d. Motor torque (percent).

e. Motor speed (rpm).

f. Set point frequency (Hz).

4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

a. Motor running.

b. Fault and warning indication (overtemperature or overcurrent).

c. Normal/Bypass Mode

d. VFD “In-Auto” mode

2.4 Line Conditioning and Filtering

A. Input Line Conditioning: Provide active front end or 18-pulse.

B. Output Filtering: Provide output reactor if shown on drawing schedule.

C. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

2.5 Additional Features

A. Communication Port: Ethernet port.

2.6 Enclosures

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Indoor Electrical Room Locations: Type 12.

2. Outdoor Locations: Type 4X stainless steel.

3. Indoor Plant Areas: Type 4X, stainless steel.

2.7 Accessories

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

1. Push Buttons: Shielded.

2. Pilot Lights: Push to test, LED.

3. Selector Switches: Rotary globe handle type.

4. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied HASP arranged so padlock can be used to lock push button in depressed position with control circuit open.

B. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

C. Supplemental Digital Meters:

1. Elapsed-time meter.

D. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4X and Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

E. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 4X and Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

F. Cooling Fan and Exhaust System: For NEMA 250, Type 12; UL 508 component recognized: Supply fan, with stainless-steel intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.

G. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

H. Spare control-wiring terminal blocks; unwired 12 points minimum.

2.8 Source Quality Control

A. Testing: Test and inspect VFDs according to requirements in NEMA ICS 61800-2.

1. Test each VFD while connected to a motor that is comparable to that for which the VFD is rated.

2. Verification of Performance: Rate VFDs according to operation of functions and features specified.

B. VFDs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

Part 3 Execution

3.1 Examination

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

B. Examine VFD before installation. Reject VFDs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the work.

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

3.2 Installation

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 26 05 29 - Hangers and Supports for Electrical Systems.

B. Floor-Mounting Controllers: Install VFDs on 4-inch nominal thickness concrete base. Comply with requirements for concrete base specified in Section 03 30 00 - Cast-in-Place Concrete.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Comply with NECA 1.

3.3 Control Wiring Installation

A. Install wiring between VFDs and remote devices and control systems. Comply with requirements in Section 26 05 23 - Control-Voltage Electrical Power Cables.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.

2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.4 Identification

A. Identify VFDs, components, and control wiring. Comply with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each VFD with engraved nameplate.

3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFDs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 Field Quality Control

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect VFD, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.

2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.

3. Test continuity of each circuit.

4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify owner before starting the motor(s).

5. Test each motor for proper phase rotation.

6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:

   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.

   b. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. VFCs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 Startup Service

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup check according to manufacturer's written instructions.

3.7 Adjusting

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping.

D. Set the ramp rate/time and current limits on reduced-voltage solid state controllers.

E. Set field-adjustable circuit-breaker trip ranges.

3.8 Protection

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFDs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 Demonstration

A. Train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFDs.

END OF SECTION

Part 1 General

1.1 Summary

A. Section includes SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

B. Related Requirements:

1. Section 26 24 16 - Panelboards for factory-installed SPDs.

1.2 Definitions

A. I-nominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SPD: Surge protective device.

H. VPR: Voltage protection rating.

1.3 Action Submittals

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, I-nominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.4 Informational Submittals

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.5 Closeout Submittals

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.6 Warranty

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.

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

Part 2 Products

2.1 General SPD Requirements

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Comply with UL 1449.

D. MCOV of the SPD shall be the nominal system voltage.

2.2 Panel Suppressors

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

1. Advanced Protection Technologies Inc. (APT).
2. Eaton Corporation.
3. Emerson Electric Co.
4. GE Zenith Controls.
5. Schneider Electric Industries SAS.

B. SPDs: Comply with UL 1449, Type 2.

1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 120 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

D. Comply with UL 1283.

E. Protection modes and UL 1449 VPR for grounded wye circuits with 120/240 V three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 120/240 V.
2. Line to Ground: 1200 V for 120/240 V.
3. Neutral to Ground: 1200 V for 120/240 V.
4. Line to Line: 2000 V for 120/240 V

2.3 Enclosures

A. Indoor Enclosures: NEMA 250, Type to match Panelboard.

2.4 Conductors and Cables

A. Power Wiring: Same size as SPD leads, complying with Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

Part 3 Execution

3.1 Installation

A. Comply with NECA 1.

B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.

C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

E. Wiring:

1. Power Wiring: Comply with wiring methods in Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

2. Controls: Comply with wiring methods in Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

3.2 Field Quality Control

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Compare equipment nameplate data for compliance with Drawings and Specifications.

2. Inspect anchorage, alignment, grounding, and clearances.

3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 Startup Service

A. Complete startup checks according to manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests and reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 Demonstration

A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

1.2 Definitions

A. BF: Ballast factor.

B. CCT: Correlated color temperature.

C. CRI: Color-rendering index.

D. HID: High-intensity discharge.

E. LED: Light-emitting diode.

F. LER: Luminaire efficacy rating.

G. Lumen: Measured output of lamp and luminaire, or both.

H. Luminaire: Complete lighting fixture, including ballast housing if provided.

1.3 Submittals

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of lighting fixture including dimensions.
2. Emergency lighting units including battery and charger.
3. Ballast, including BF.
4. Energy-efficiency data.
5. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
6. Emergency lighting management system.

7. Wiring Diagrams: For power, signal, control wiring, communication, equipment.

8. Installation instructions.

1.4 Quality Assurance

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing & Calculation Guides.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NFPA 70.

E. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

1.5 Coordination

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.6 Warranty

A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.

2. Warranty Period for Emergency Fluorescent Ballast and Self-Powered Exit Sign Batteries: Ten years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.

Part 2 Products

2.1 Manufacturers

A. Products: Products indicated on Drawings are basis of design. Contractor submitting alternate products shall demonstrate equivalency of proposed products to basis of design in photometric and energy performance and physical appearance. Calculations shall be performed by an IESNA Certified Lighting Consultant (LC) or licensed professional engineer with expertise in lighting, registered in the state of Tennessee.

2.2 General Requirements for Lighting Fixtures and Components

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

C. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.

D. Metal Parts: Free of burrs and sharp corners and edges.

E. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

G. Diffusers and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

    a. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

    b. UV stabilized.

2. Glass: Annealed crystal glass unless otherwise indicated.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp and ballast characteristics:

a. "USE ONLY" and include specific lamp type.

b. CCT and CRI for all luminaires.

I. Electromagnetic-Interference Filters (where scheduled): Factory installed to suppress conducted electromagnetic interference as required by MIL-STD-461E. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.

2.3 LED Driver/Engine

A. Driver: UL Listed, power factor > 90% and THD < 20 % at full load; complies with FCC rules and regulations, Title 47 CFR Part 15 Non-Consumer (Class A), 100,000 hours expected life (≤ 0.5% failure at 100,000 hours of operation in 25 degree C ambient).

B. Integral 10 kV surge protection tested in accordance with IEE/ANSI C62.41.

C. Serviceable and upgradable light engine.

D. Passive heat sink.

2.4 LED Lamp Assembly

A. Efficacy: 90 lumens per watt minimum.

B. CRI: 90.

C. CCT: 4000K unless notified otherwise on the drawings.

2.5 Exit Signs

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.

2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

a. Battery: Sealed, maintenance-free, nickel-cadmium type.

b. Charger: Fully automatic, solid-state type with sealed transfer relay.

c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.

e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

f. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.6 Emergency Lighting Units

A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type.

2. Charger: Fully automatic, solid-state type with sealed transfer relay.

3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.

5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.

2.7 Lighting Fixture Support Components

A. Comply with Section 26 05 29 - Hangers and Supports for Electrical Systems for channel- and angle-iron supports, and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.

F. Rod Hangers: 3/8-inch minimum diameter, cadmium-plated, threaded steel rod.

G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

Part 3 Execution

3.1 Installation

A. Lighting fixtures:

1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.

2. Install lamps in each luminaire.

B. Temporary Lighting: If it is necessary, and approved by Owner’s Representative, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.

C. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.

1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches from lighting fixture corners.

2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.

3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

D. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.

2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.

3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.

E. Provide all conduit and wiring needed for emergency lighting management system. Cable trays may be used for network communications routing.

F. Connect wiring according to Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

3.2 Identification

A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.

3.3 Field Quality Control

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.4 Startup Service

A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in lamps intended to be dimmed, for at least 100 hours at full voltage.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Poles and accessories for support of luminaires.

1.2 Definitions

A. EPA: Equivalent projected area.

B. Luminaire: Complete luminaire.

C. Pole: Luminaire-supporting structure, including tower used for large-area illumination.

D. Standard: See "Pole."

1.3 Submittals

A. Product Data: For each pole, accessory, and luminaire-supporting and -lowering device, arranged as indicated.

1. Include data on construction details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.

2. Include finishes for lighting poles and luminaire-supporting devices.

3. Anchor bolts.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.

2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Detail fabrication and assembly of poles and pole accessories.

4. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.

5. Anchor bolt templates keyed to specific poles and certified by manufacturer.

6. Method and procedure of pole installation. Include manufacturer's written installations.

C. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements according to AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations signed and sealed by a professional engineer.

D. Field quality-control reports.

1.4 Closeout Submittals

A. Operation and Maintenance Data: For poles to include in emergency, operation, and maintenance manuals.

1. Include pole operation and maintenance data, pole inspection and repair procedures.

1.5 Maintenance Material Submittals

A. Pole repair materials.

1.6 Delivery, Storage, and Handling

A. Package aluminum poles for shipping according to ASTM B660.

B. Store poles on decay-resistant skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Retain factory-applied pole wrappings on metal poles until right before pole installation. Handle poles with web fabric straps.

Part 2 Products

2.1 Performance Requirements

A. Structural Characteristics: Comply with AASHTO LTS-6-M.

B. Dead Load: Weight of luminaire and its horizontal and vertical supports and supporting structure, applied according to AASHTO LTS-6-M.

C. Live Load: Single load of 500 lbf distributed according to AASHTO LTS-6-M.

D. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to AASHTO LTS-6-M.

1. Basic wind speed for calculating wind load for poles 50 feet high or less is 90 mph.

    a. Wind Importance Factor: 1.0.

    b. Minimum Design Life: 25 years.

    c. Velocity Conversion Factor: 1.0.

E. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA to be used in pole selection strength analysis.

F. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

2.2 Aluminum Poles

A. Manufacturers: Subject to compliance with requirements, provide products as scheduled to equivalent product by:

1. Cooper Lighting, an Eaton business.
2. Hapco.
3. Hubbell Incorporated.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. LSI Industries.
6. Lyte Poles Incorporated.
7. Union Metal Corporation.
8. Valmont Industries, Inc.

B. Poles: Seamless, extruded structural tube complying with ASTM B221, Alloy 6061-T6, with access handhole in in pole wall.

1. Shape: Round, tapered unless otherwise indicated.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with stainless-steel bolts.

2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

E. Grounding and Bonding Lugs: Bolted 1/2-inch threaded lug, complying with requirements in Section 26 05 26 - Grounding and Bonding for Electrical Systems, listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

F. Fasteners: Stainless steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as to substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.

2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

G. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.

H. Aluminum Finish (Where Scheduled): Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.

3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I clear coating of 0.018 mm or thicker), complying with AAMA 611.

I. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2. Powder coat shall comply with AAMA 2604.

   a. Electrostatic applied powder coating; single application with a minimum 2.5- to 3.5-mils dry film thickness; cured according to manufacturer's instructions. Coat interior and exterior of pole for equal corrosion protection.

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

2.3 Pole Accessories

A. Duplex Receptacle: Ground-fault circuit interrupter type, 120 V ac, 20 A in a weatherproof assembly. Comply with requirements in Section 26 27 26 - Wiring Devices.

   1. Recessed 12 inches above finished grade.

      a. NEMA 250, Type 3R, non-metallic polycarbonate plastic or reinforced fiberglass, enclosure with cover; color to match pole.

      b. Lockable hasp and latch complying with OSHA lockout and tag-out requirements.

B. Base Covers: Manufacturers' standard metal units, finished same as pole, and arranged to cover pole's mounting bolts and nuts.

2.4 Mounting Hardware

A. Anchor Bolts: Manufactured to ASTM F1554, Grade 55, with a minimum yield strength of 55,000 psi.

   1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.

   2. Headed rods diameter and length per pole manufacturer to meet loading herein.

   3. Threading: Uniform National Coarse, Class 2A.

B. Nuts: ASTM A563, Grade A, Heavy-Hex.

   1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.

   2. Four nuts provided per anchor bolt.

C. Washers: ASTM F436, Type 1.

   1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.

   2. Two washer(s) provided per anchor bolt.

2.5 General Finish Requirements

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

Part 3 Execution

3.1 Examination

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

B. Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.

C. Examine roughing-in for foundation and conduit to verify actual locations of installation.

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

3.2 Pole Foundation

A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A36/A36M and hot-dip galvanized according to ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories.

B. Anchor Bolts: Install plumb using manufacturer-supplied plywood template, uniformly spaced.

3.3 Pole Installation

A. Alignment: Align poles as indicated.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on drawing.

1. Fire Hydrants and Water Piping: 60 inches.

2. Water, Gas, Electric, Communications, and Sewer Lines: 10 feet unless otherwise indicated.

3. Trees: 15 feet from tree trunk minimum; farther if required to be outside “dripline.”.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer.

D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level according to pole manufacturer's written instructions.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.

2. Grout void between pole base and foundation. Use non-shrink or expanding concrete grout firmly packed to fill space.

3. Install base covers unless otherwise indicated.

4. Use a short piece of 1/2 -inch diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Poles and Pole Foundations Set in Concrete-Paved Areas: Install poles with a minimum 6-inch- wide, unpaved gap between the pole or pole foundation and the edge of the adjacent concrete slab. Fill unpaved ring with pea gravel. Insert material to a level 1 inch below top of concrete slab.

F. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

3.4 Corrosion Prevention

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.

B. Steel Conduits: Comply with requirements in Section 26 05 33 - Raceways and Boxes for Electrical Systems. In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50-percent overlap.

3.5 Grounding

A. Ground Metal Poles and Support Structures: Comply with requirements in Section 26 05 26 - Grounding and Bonding for Electrical Systems.

1. Install grounding electrode for each pole unless otherwise indicated.

2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

3.6 Identification

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.

3.7 Field Quality Control

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Inspect poles for nicks, mars, dents, scratches, and other damage.

2. System function tests.

END OF SECTION

Part 1 General

1.1 Summary

A. Section Includes:

1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.

2. Luminaire supports.

B. Related Requirements:

1. Lighting Control Devices for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.2 Definitions

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 Submittals

A. Product Data: For each type of luminaire.

1. Arrange in order of luminaire designation.

2. Include data on features, accessories, and finishes.

3. Include physical description and dimensions of luminaire.

4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.

5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.

a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.

6. Wiring diagrams for power, control, and signal wiring.

7. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.

2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Include diagrams for power, signal, and control wiring.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

D. Product Certificates: For each type of the following:

1. Luminaire.

E. Product Test Reports: For each luminaire, for tests performed by manufacturer and a qualified testing agency.

F. Source quality-control reports.

1.4 Closeout Submittals

A. Operation and Maintenance Data: For luminaires and photoelectric relays to include in operation and maintenance manuals.

1. Provide a list of all larenewal parts including LED boards and drivers.

2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.5 Quality Assurance

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

1.6 Delivery, Storage, And Handling

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.7 Field Conditions

A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.

B. Mark locations of exterior luminaires for approval by Owner's Representative prior to the start of luminaire installation.

Part 2 Products

2.1 Luminaire Requirements

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. UL Compliance: Comply with UL 1598 and listed for wet location.

D. CRI of minimum 70. CCT of 4100 K.

E. L70 lamp life of 100,000 hours.

F. Lamps dimmable from 100 percent to 0 percent of maximum light output.

G. Internal driver.

H. Nominal Operating Voltage: 277 V ac unless otherwise scheduled.

I. In-line Fusing: Separate in-line fuse for each luminaire.

J. Source Limitations: Obtain luminaires from single source from a single manufacturer.

2.2 Luminaire Types

A. Area and Site:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings. Alternate manufacturers require approval prior to bids. Approval will require product data and photometric calculations performed and certified by LC or Professional Engineer.

2.3 Materials

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum or stainless steel. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

2. Glass: Annealed crystal glass unless otherwise indicated.

3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.

2. Specular Surfaces: 83 percent.

3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.

2. Provide filter/breather for enclosed luminaires.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.

b. Lamp diameter, shape, size, wattage and coating.

c. CCT and CRI for all luminaires.

2.4 Finishes

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.

3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.

a. Color: As selected by the Architect.

C. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

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

2.5 Luminaire Support Components

A. Comply with requirements in Section 26 05 29 - Hangers and Supports for Electrical Systems for channel and angle iron supports and non-metallic channel and angle supports.

Part 3 Execution

3.1 Examination

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

B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls, roofs, canopy ceilings, and overhang ceilings for suitable conditions where luminaires will be installed.

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

3.2 Temporary Lighting

A. If approved by the Owner’s Representative, use selected permanent luminaires for temporary lighting.

3.3 General Installation Requirements

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:

1. Sized and rated for luminaire weight.

2. Able to maintain luminaire position after cleaning and relamping.

3. Support luminaires without causing deflection of finished surface.

4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls or Attached using through bolts and backing plates on either side of wall as applicable.

G. Wiring Method: Install cables in raceways. Conceal raceways and cables.

H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming.

K. Comply with requirements in Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables and Section 26 05 33 - Raceways and Boxes for Electrical Systems for wiring connections and wiring methods.

3.4 Corrosion Prevention

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 26 05 33 - Raceways and Boxes for Electrical Systems. In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.5 Identification

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.

3.6 Field Quality Control

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

C. Illumination Tests:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.7 Demonstration

A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

END OF SECTION

Part 1 General

1.1 Scope

A. This Section includes earthwork and related operations, including, but not limited to, excavating all classes of material, handling, storage, transportation and disposal of all excavated and unsuitable or excess material, construction of fill material areas, placing and replacing fill materials around structures and pipe, placing and replacing fill materials for all trenches and pits, compacting, all sheeting, shoring and bracing, preparation of subgrades, finished grading, and any other similar, incidental, or appurtenant earthwork operations which may be necessary to properly complete the work.

B. The Contractor shall provide all services, labor, materials, and equipment required for all earthwork and related operations, necessary or convenient to the Contractor, for furnishing complete work as shown on the Drawings or specified in these Contract Documents.

C. Excavation work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the work, regardless of the type, character, composition, or condition of the material.

1.2 Existing Information

A. The elevations shown on the Drawings as existing are taken from existing data and are intended to give reasonably accurate information about the existing elevations. They are not precise, and the Contractor shall become satisfied as to the exact quantities of excavation and fill required.

B. Known subsurface conditions as described in the Supplementary Conditions of these Specifications.

1.3 Quality Assurance

A. Approval Required: All earthwork materials shall be subject to the approval of the Engineer.

B. Tests for compaction and density shall be conducted by the Engineer or by an independent testing laboratory selected and in accordance with Section 01 45 29 these Specifications.

1. The soils testing laboratory is responsible for the following:

   a. Field compaction testing shall be based on using the maximum dry density determined by the Standard Proctor Compaction Test in accordance with ASTM D 698.

b. Maximum dry density for non-cohesive materials shall mean the maximum index density as determined by the “Maximum Index Density of Soils Using a Vibratory Table”, ASTM D 4253.

c. Determination of in-place fill material density shall be done in accordance with ASTM D 1556, “Density of Soil in Place by the Sand Core Method”, ASTM D 2937, “Density of Soil in Place by the Drive-Cylinder Method” or ASTM D 6938, “In-Place Density/Water Content of Soil/Soil Aggregate by Nuclear Methods Shallow Depth”.

d. Field density tests for each two feet of vertical fill material; with at least one test for each 5,000 square feet of fill material.

e. Inspecting and testing of stripped site, subgrades and proposed fill materials.

2. Contractor's duties relative to testing include:

a. Notifying laboratory of conditions requiring testing.

b. Coordinating with laboratory for field testing.

c. Providing representative fill material soil samples to the laboratory for test purposes. Provide 50-pound samples of each fill soil.

3. Inspection

a. Earthwork operations, suitability of excavated fill materials, and placing and compaction of fill materials are subject to inspection. Engineer will observe earthwork operations.

b. Foundations and shallow spread footing foundations are required to be reviewed by the Engineer to verify suitable bearing and construction.

C. All earthwork operations shall comply with the requirements of OSHA Construction Standards, Part 1926, Subpart P, Excavations, Trenching, and Shoring, and Subpart O, Motor Vehicles, Mechanized Equipment, and Marine Operations, and shall be conducted in a manner acceptable to the Engineer.

D. It is understood and agreed that the Contractor has made a thorough investigation of the surface and subsurface conditions of the site and any special construction problems which might arise as a result of nearby watercourses and floodplains, particularly in areas where construction activities may encounter water-bearing sands and gravels, or limestone solution channels. The Contractor shall be responsible for providing all services, labor, equipment, and materials necessary or convenient to the Contractor for completing the work within the time specified in these Contract Documents.

Part 2 Products

2.1 Fill Materials

A. Fill Material, General

1. Approval Required: All fill material shall be subject to the approval of the Engineer.

2. Notification: For approval of imported fill material, notify the Engineer and testing laboratory at least one week in advance of intention to import material, designate the proposed borrow area, and permit testing as necessary to prove the quality of the material.

B. On-Site Fill Material

1. On-site fill material shall be soil exclusive of organic matter, frozen lumps, or other deleterious substances which may be compressible, or which cannot be properly compacted.

2. On-site fill material shall contain no rocks or lumps over 3-inches maximum in dimension.

C. Imported Fill Materials: All imported fill material shall meet the requirements of on-site fill material.

D. Structural Fill Material shall consist of soil exclusive of organic matter, frozen lumps, or other deleterious substances which may be compressible, or which cannot be properly compacted. Structural Fill Material shall have the following gradation:

Sieve Size	% Passing

2.2 Aggregate

A. Coarse Aggregate or Crushed Stone: Coarse aggregate shall conform to the Georgia Department of Transportation Standard Specifications for Construction of Road and Bridges, 800, size No. 57, Group II

B. Fine Aggregate: All fine aggregate shall conform to the Georgia Department of Transportation Standard Specifications for Construction of Road and Bridges, 801.01.

C. GA Graded Aggregate (GAB): Graded Aggregate shall conform to the Georgia Department of Transportation Standard Specifications for Construction of Roads and Bridges, 815

D. Pea Gravel: Pea gravel shall be clean, naturally rounded aggregate, 1/8 to 3/4-inch in diameter per ASTM C 33.

2.3 Topsoil

A. Topsoil is defined as the top layer of soil and should consist of dark organic weed free loam, free of muck.

2.4 Construction Materials

A. Sheeting, Bracing and Timbering: The Contractor shall furnish, place and maintain all sheeting, bracing and timbering required to properly support trenches and other excavations in open cut and to prevent all movement of the soil, pavement, structures, or utilities outside of the trench or pit.

1. General

    a. Cofferdams and bracing design, including computations, shall be prepared before commencing construction operations. Drawings and design computations shall be signed and sealed by a registered professional engineer licensed in the state in which the Project is located. The Drawings and design computations shall not be submitted to the Engineer.

    b. Sheeting, bracing and timbering shall be so placed as to allow the work to be constructed to the lines and grades shown on the Drawings and as ordered by the Engineer.

    c. If at any time the method being used by the Contractor for supporting any material or structure in or adjacent to any excavation is not reasonably safe, the Contractor shall provide additional bracing and support necessary to furnish the added degree of safety.

    d. All sheeting in contact with the concrete or masonry shall be cut off as directed by the Engineer and left in place.

2.5 Other Materials

A. All other materials not specifically described but required for proper completion of the work of this Section shall be as selected by the Contractor subject to the approval of the Engineer.

Part 3 Execution

3.1 General

A. Safety: Comply with local regulations and with the provisions of the “Manual of Accident Prevention in Construction” of the Associated General Contractors of America, Inc., Occupational Safety and Health Act and all other applicable safety regulations.

B. Earthwork operations shall be performed in a safe and proper manner with appropriate precautions being taken against all hazards.

C. All excavated and filled areas for structures, trenches, fills, topsoil areas, embankments, and channels shall be maintained by the Contractor in good condition at all times until final acceptance by the Owner. All damage caused by erosion or other construction operations shall be repaired by the Contractor using material of the same type as the damaged material.

D. The Contractor shall control grading in a manner to prevent surface water from running into excavations. Obstruction of surface drainage shall be avoided and means shall be provided whereby storm water flow can be uninterrupted in existing gutters, other surface drains, or temporary drains. Free access must be provided to all fire hydrants, meters, and other areas and utilities that may need to be accessed.

E. Topsoil

1. Remove all topsoil to the full layer depth and at which depth the subsoil is encountered, from all areas under buildings, pavements, and from all areas which are to be cut to lower grades or filled.

2. With the Engineer's approval, topsoil to be used for finish grading may be stored on the site.

3. Other topsoil may be used for fill in non-critical areas with approval of the Engineer.

4. Properly dispose of all excess topsoil off site.

F. Bracing and Sheeting

1. Furnish, put in place, and maintain all sheeting, bracing, and shoring as may be required to properly support the sides of all excavations and to prevent all movement of earth which could in any way injure the work, adjacent property or workers.

2. Properly support all excavations in locations indicated on the Drawings and where necessary to conform to all pertinent rules and regulations and these Specifications, even though such locations are not indicated on the Drawings.

3. Exercise care in the removal of sheeting, shoring, bracing and timbering to prevent collapse or caving of the excavation faces being supported and damage to the work and adjacent property.

4. Do not leave any sheeting or bracing in the trench or excavation after completion of the work, unless approved by the Engineer.

G. Obstructions

1. Remove and dispose of all trees, stumps, roots, boulders, sidewalks, driveways, pavement, pipes, and the like, as required for the performance of the work.

2. Exercise care in excavating around catch basins, inlets and manholes so as to not disturb or damage these structures.

3. Avoid removing or loosening castings or pushing dirt into catch basins, inlets and manholes.

4. Damaged or displaced structures or castings shall be repaired or replaced and dirt entering the structures during the performance of the work shall be removed at no additional cost to the Owner.

H. Utilities to be Abandoned or Removed

1. When pipes, conduits, sewers, or other structures are removed from the trench, leaving dead ends in the ground, such ends shall be fully plugged or sealed with brick and non-shrink grout.

2. Abandoned structures such as manholes or chambers shall be entirely removed unless otherwise specified or indicated on the Drawings.

3. All materials from abandoned utilities which can be readily salvaged shall be removed from the excavation and stored on the site at a location as directed by the Owner.

I. All salvageable materials will remain the property of the Owner unless otherwise indicated by the Owner.

J. Cutting Paved Surfaces and Similar Improvements

1. Remove existing pavement as necessary for installing pipe utilities and appurtenances or as otherwise shown on the Drawings.

2. Before removing any pavement, mark the pavement neatly, paralleling pipe lines and existing street lines. Space marks the width of the trench.

3. Break asphalt pavement along the marks using jack hammers or other suitable tools. Break concrete pavement along the marks by use of jack hammers or by scoring with a rotary saw and breaking below the score by the use of jack hammers or other suitable tools.

4. Do not pull pavement with machines until completely broken and separated from pavement to remain.

5. Do not disturb or damage the adjacent pavement. If the adjacent pavement is disturbed or damaged, remove and replace the damaged pavement. No additional payment will be made for removing and replacing damaged adjacent pavement.

6. Remove and replace sidewalks disturbed by construction for their full width and to the nearest undisturbed joint.

7. The Contractor may tunnel under curbs that are encountered. Remove and replace any curb disturbed by construction to the nearest undisturbed joint.

K. Stockpile Area: The stockpile area shown on the Drawings shall be used to stockpile soil material for backfilling around structures and to stockpile needed topsoil.

3.2 Excavation

A. Method

1. All excavation shall be by open cut from the surface except as indicated on the Drawings.

2. All excavations for pipe appurtenances and structures shall be made in such a manner, and to such depth and width, as will give ample room for building the structures, and for bracing, sheeting, and supporting the sides of the excavation, for pumping and draining groundwater which may be encountered, and for the removal from the excavation of all materials excavated.

3. Take special care so that the soil below the bottom of the structure to be built is left undisturbed.

B. Grades: Excavate to grades indicated on the Drawings. Where excavation grades are not indicated on the Drawings, excavate as required to accommodate installation.

C. Disposal of Excavated Material

1. Remove and properly dispose of all excavated material not needed to complete filling, backfilling and grading.

D. Dispose of excess excavated fill material, as defined in Part 2 of this Section, at locations on-site designated by the Engineer and in accordance with all requirements of federal, state, county, and municipal regulations. No debris of any kind shall be deposited in any stream or body of water, or on any street or alley. No debris shall be deposited on any private property, except by written consent of the property owner. In no case shall any debris material be left on the Project, shoved onto abutting private properties, or be buried in embankments or trenches on the Project.

E. Dispose of excess excavated rock material weighing less than 500 pounds at locations on-site designated by the Engineer and in accordance with all requirements of federal, state, county, and municipal regulations. No debris of any kind shall be deposited in any stream or body of water, or on any street or alley. No debris shall be deposited on any private property, except by written consent of the property owner. In no case shall any material be left on the Project, shoved onto abutting private properties, or be buried in embankments or trenches on the Project.

F. Dispose of all other excavated materials including but not limited to soil that does not meet the requirements of this Section and rock material weighing greater than 500 pounds, at off-site locations secured by the Contractor and in accordance with all requirements of federal, state, county, and municipal regulations. No debris of any kind shall be deposited in any stream or body of water, or on any street or alley. No debris shall be deposited on any private property, except by written consent of the property owner. In no case shall any material be left on the Project, shoved onto abutting private properties, or be buried in embankments or trenches on the Project.

G. Extra Earth Excavation

1. If soft or excessively wet material which, in the opinion of the Engineer is not suitable for construction, is encountered below the final subgrade elevation of an excavation or underneath a structure, the Engineer may order the removal of this material and its replacement with crushed stone or other suitable material in order to make a suitable foundation for the construction of the structure.

3.3 Excavating for Structures

A. This Article applies to all structures except as modified in Article 3.6.

B. Earth Excavation: Earth excavation shall include all substances to be excavated other than rock. Earth excavation for structures shall be to limits not less than two feet outside wall lines, to allow for formwork and inspection, and further as necessary to permit the trades to install their work. All materials loosened or disturbed by excavation shall be removed from surfaces to receive concrete or graded aggregate.

C. Rock Excavation

1. Definition of Rock: Any material which cannot be excavated with conventional excavating equipment, and must be removed by drilling and blasting, and occupies an original volume of at least one-half cubic yard.

2. Excavation: Where rock is encountered within excavation for structures, it shall be excavated to the lines and grades indicated on the Drawings, or as otherwise directed by the Engineer. The Contractor shall be responsible for obtaining any blasting permits required.

3. Blasting: Blasting operations shall be conducted in accordance with all existing ordinances and regulations. All structures shall be protected from the effects of the blast. The blasting shall be done by licensed experienced workers. Dispose of excavated rock in accordance with applicable federal, state, county, and local regulations and in accordance with this Section.

   a. If, in the sole opinion of the Engineer, the Contractor persistently uses excessive blasting charges or blasts in an unsafe or improper manner, the Engineer will direct the Contractor to employ an independent, qualified blasting consultant, approved by the Engineer, to supervise the preparation for each blast and approve the quantity of each charge.

   b. The Contractor will notify the Engineer before any charge is set and prior to blasting. Following review by the Engineer regarding the proximity (normally within 300 linear feet) of permanent structures to the blasting site, the Engineer may direct the Contractor to employ an independent qualified specialty subcontractor, approved by the Engineer, to monitor the blasting by use of seismograph, identify areas where light charges must be used, conduct pre-event and post-event inspections of all structures, including photographs or videos, and maintain a detailed written log.

c. Any damage caused as a result of blasting operations shall be promptly repaired by the Contractor at the Contractor's own expense.

4. No allowance shall be made for overcutting or for excavation below the required elevations. The Engineer must be given reasonable notice to measure all rock.

D. If excess excavation is made or the material becomes disturbed so as to require removal below final subgrade elevations or beyond the prescribed limits, the resulting space shall be refilled with Group II Class “C” concrete in accordance with Section 03 30 00 of these Specifications.

E. Excavation for Foundations: Foundations and slabs-on-grade shall rest on undisturbed earth, rock or compacted materials to ensure proper bearing.

F. Unsuitable Foundation Material: Any material, in the opinion of the Engineer, which is unsuitable for foundation shall be removed and replaced with compacted graded aggregate, with Group II, class “C” concrete or with compacted fill material as directed by the Engineer. No determination of unsuitability will be made until all requirements for dewatering are satisfactorily met.

G. Foundation in Rock: Foundations for a structure shall be on similar materials. Should excavation for a foundation bearing on earth be partially in rock, the Contractor shall undercut that portion of the rock 24-inches and bring the excavation to bearing elevation with compacted graded aggregate.

H. Pipe Trenches Beneath Structures: Where piping or conduit passes beneath footings or slabs resting on grade, trenches shall be excavated to provide a minimum 6-inch clearance from all surfaces of the pipe or conduit. The trench shall be backfilled to the base of the structure with crushed stone or as shown on the Drawings.

I. Unauthorized Excavation: Care shall be taken that excavation does not extend below bottom levels of foundations or slabs on earth or rock. Should the excavation be carried below such levels, the Contractor shall fill in the resulting excess excavation with concrete under foundations and compacted graded aggregate or other material approved by the Engineer under slabs-on-grade. Should excavation be carried beyond outside lines of footings, such excess excavation shall be filled with concrete, or formwork shall be provided, as directed by the Engineer.

J. Unsuitable Bearing

1. If suitable bearings for foundations as directed by the Engineer are not encountered at the elevations indicated on the Drawings, immediately notify the Engineer.

2. Do not proceed further until instructions are received and necessary measurements made for purposes of establishing additional volume of excavation.

3.4 Compaction

A. Fill materials supporting roadways, parking areas, sidewalks, structures, and buildings and placed around structures above undisturbed earth shall be compacted to 95 percent of the maximum dry density. The top 12-inches of fill materials supporting structures or pavement shall be compacted to 98 percent of the maximum dry density. Fill materials placed for general site grading shall be compacted to 92 percent of the maximum dry density.

B. Compaction of fill materials on slopes steeper than 6 feet horizontal to 1 foot vertical shall be by sheepsfoot rollers with staggered, uniformly spaced knobs and suitable cleaning devices. The projected area of each knob and the number and spacing of the knobs shall be such that the total weight of the roller and ballast when distributed over the area of one row of knobs shall be 250 psi. Placement and compaction of materials shall extend beyond the final contours sufficiently to ensure compaction of the material at the resulting final surface. Final contours shall then be achieved by a tracked bulldozer shaping the face of the slope.

C. Compaction of fill materials around structures shall be accomplished by heavy power tamping equipment such as a jumping jack.

D. If tests indicate that density of fill material is less than that specified, the area shall be either recompacted or undercut, replaced with fill material, and compacted until specified density is achieved.

3.5 Placing Fill Materials

A. Controlled Fill

1. The fill material placed for roadways, parking areas, walks, structures, and building slabs-on-grade shall be known as controlled fill material.

2. After the existing ground or excavated area has been proofrolled and examined by the Engineer, all holes and other irregularities shall be filled and compacted before the main fill material is placed.

B. The fill material shall be placed in even layers not exceeding 8 -inches in depth and shall be thoroughly compacted as herein specified.

C. If an analysis of the soil being placed shows a marked difference from one location to another, the fill being placed shall not be made up of a mixture of these materials.

D. Each different type of material shall be handled continuously so that field control of moisture and density may be based upon a known type of material.

E. No fill shall be placed following a heavy rain without first making certain on isolated test areas that compaction can be obtained without damage to the already compacted fill.

F. Proofrolling

1. All areas where roadways, parking areas, sidewalks, structures, and buildings are to be constructed on cut areas, compacted fill material areas, and other areas where indicated on the Drawings, shall be proofrolled to detect soft spots prior to and following placement of fill materials.

G. Proof rolling shall consist of the moving of a 20-30 ton loaded dump truck or other pneumatic tire roller over the specified areas prior to and following placement of fill materials.

H. Proofrolling shall be witnessed by the Engineer.

I. Subgrade shall be proofrolled with six passes of the truck or roller. Depressions that develop during the proofrolling operation shall be filled with suitable material and those filled areas shall be proofrolled with six passes of the roller. If, after having been filled and proofrolled, the subgrade still contains depressions, the area shall be undercut to the full depth of the soft material or five feet, whichever is less, backfilled, recompacted, and rolled to achieve a subgrade acceptable to the Engineer.

J. After the proofrolled subgrade has been accepted by the Engineer, the surface of the subgrade shall be finish rolled with a smooth steel wheel roller weighing not less than 10 tons. Finished surface of the subgrade shall be within a tolerance of 1/4-inch at every point.

K. Conduits, pipes, culverts, and underdrains shall be neither disturbed nor damaged by proofrolling operations. Rollers shall neither pass over, nor approach closer than five feet to, conduits, pipes, culverts, and underdrains unless the tops of those utilities are deeper than three feet.

L. Placement

1. Prior to placement of any material on slopes steeper than 6 feet horizontal to 1 foot vertical, the area within the slope limits shall then be scarified to a depth of at least 6-inches.

2. Fill materials shall be placed in continuous, approximately horizontal layers extending the full width of the embankment cross-section and the full dimension of the excavation where practical and having a net compacted thickness of not over 6-inches.

3. Place fill material carefully to restore the ground surface to its original condition. Dispose of excess material in accordance with this Section.

M. Placement Around Structures

1. Remove debris from excavations before placement.

2. Do not place fill materials against walls until so directed by the Engineer nor until all indicated perimeter insulation and/or waterproofing is in place.

3. Protect such insulation and/or waterproofing during filling operations.

4. Wherever possible, placement shall be simultaneous on both sides of walls to equalize lateral pressures.

5. Do not place fill materials against walls until all permanent construction is in place to furnish lateral support on both top and bottom of wall.

6. Placement against walls shall take place only after all the concrete in the affected members has attained the specified strengths.

N. Final Grading: Upon completion of construction operations, the area shall be graded to finish contour elevations and grades shown on the Drawings. Graded areas shall be made to blend into conformation with remaining ground surfaces. All surfaces shall be left smooth and free to drain.

O. Excess Material: Surfaces and slopes of waste fills shall be left smooth and free to drain.

P. Moisture

1. Fill materials shall be placed at optimum moisture content within practicable limits, but not less or more than [two] percent of optimum. Optimum moisture shall be maintained by sprinkling the layers as placed or by allowing materials to dry before placement.

2. If fill material is too wet, provide and operate means approved by the Engineer to assist the drying of the fill until suitable for compaction.

3. If fill material is too dry, provide and operate means approved by the Engineer to add moisture to the fill layers.

3.6 Special Earthwork Provisions for Structures

A. General

1. Notify the Engineer if conditions differ from those identified on the Drawings, in these Specifications or defined in the Geotechnical Report listed in Supplementary Conditions of these Specifications.

2. Except as modified in this Article, all other requirements of Part 3 of this Specification apply.

B. Deep foundations are recommended for the following structures:

1. Valves

2. Piping

3. Electrical Room Structures

C. The Contractor shall be responsible for hiring a design-build contractor to design these deep foundations.

3.7 Grading

A. General: Perform all rough and finish grading required to attain the elevations indicated on the Drawings. Perform finish grading to an accuracy of 1/4-inch.

B. Compact backfill underlying roadways, parking areas, sidewalks, structures and buildings in accordance with Article 3.4 of this Section.

C. Backfilling around structures shall be performed in accordance with Article 3.6 of this Section.

D. Treatment After Completion of Grading

1. After grading is completed, permit no further excavation, filling or grading, except with the approval of the Engineer.

2. Use all means necessary to prevent the erosion of freshly graded areas during construction and until such time as permanent drainage and erosion control measures have been installed.

3.8 Surface Water Control

A. Regulations and Permits: Obtain all necessary soil erosion control permits in accordance with the Georgia Soil Erosion and Sedimentation Control Act and all pertinent rules, laws, and regulations of all applicable federal, state, county and municipal regulatory agencies.

B. Unfavorable Weather: Do not place, spread or roll any fill material during unfavorable weather conditions. Do not resume operations until moisture content and fill density are satisfactory to the Engineer.

C. Provide berms or channels to prevent flooding of subgrade. Promptly remove all water collected in depressions.

D. Pumping and Drainage

1. Provide, maintain and use at all times during construction adequate means and devices to promptly remove and dispose of all water from every source entering the excavations or other parts of the work.

2. Dewater by means which will ensure dry excavations, preserve final lines and grades, do not disturb or displace adjacent soil.

3. All pumping and drainage shall be performed with no damage to property or structures and without interference with the rights of the public, owners of private property, pedestrians, vehicular traffic or the work of other contractors, and in accordance with all pertinent laws, ordinances and regulations.

4. Do not overload or obstruct existing drainage facilities.

3.9 Settlement

A. The Contractor shall be responsible for all settlement of backfill, fills and embankments which may occur within one year after final acceptance of the work by the Owner.

B. The Contractor shall make, or cause to be made, all repairs or replacements made necessary by settlement within 30 days after receipt of written notice from the Engineer or Owner.

3.10 Cleaning

A. Upon completion of the work of this Section, remove all rubbish, trash, and debris resulting from construction operations. Remove surplus equipment and tools. Leave the site in a neat and orderly condition acceptable to the Engineer, and in conformance with Section 01 74 00 of these Specifications.

END OF SECTION

Part 1 General

1.1 Section Includes

A. Clearing and grubbing.

B. Excavation and disposal of all wet and dry materials (including rock) encountered that must be removed for construction purposes.

C. Sheeting, shoring, bracing, and timbering.

D. Dewatering of trenches and other excavations.

E. Pipe bedding.

F. Backfilling and tamping of trenches, foundations, and other structures.

1.2 Definitions

A. Degree of Compaction: Degree of compaction is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D698for general soil types, abbreviated as percent laboratory maximum density.

B. Hard Materials: Weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" but which usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

C. Rock: Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement.

1.3 Submittals

A. The following shall be submitted in accordance with Section 01 33 00 - Submittal Procedures:

B. Preconstruction Submittals - Submit 15 days prior to starting work:

1. Shoring and Sheeting Plan.

2. Dewatering work plan.

C. Test Reports – Submit copies of all laboratory and field test reports within 24 hours of the completion of the test.

1. Borrow Site Testing: Fill and backfill test.

2. Select material test.

3. Porous fill test for capillary water barrier.

4. Density tests.

5. Moisture Content Tests.

1.4 Delivery, Storage, and Handling

A. Perform in a manner to prevent contamination or segregation of materials.

1.5 Requirements for Off Site Soil

A. Soils brought in from off site for use as backfill shall be tested for petroleum hydrocarbons, BTEX, PCBs and HW characteristics (including toxicity, ignitability, corrosivity, and reactivity). Backfill shall not contain concentrations of these analytes above the appropriate State and/or EPA criteria, and shall pass the tests for HW characteristics. Determine petroleum hydrocarbon concentrations by using appropriate State protocols. Determine BTEX concentrations by using EPA SW-846.3-3 Method 5035/8260B. Perform complete TCLP in accordance with EPA SW-846.3-3 Method 1311. Perform HW characteristic tests for ignitability, corrosivity, and reactivity in accordance with accepted standard methods. Perform PCB testing in accordance with accepted standard methods for sampling and analysis of bulk solid samples. Provide borrow site testing for petroleum hydrocarbons and BTEX from a grab sample of material from the area most likely to be contaminated at the borrow site (as indicated by visual or olfactory evidence), with at least one test from each borrow site. For each borrow site, provide borrow site testing for HW characteristics from a composite sample of material, collected in accordance with standard soil sampling techniques. Do not bring material onsite until tests results have been received and approved by the Owner.

1.6 Field Measurements

A. Verify that survey bench mark and intended elevations for the Work are as shown on the drawings.

1.7 Coordination

A. Verify work associated with lower elevation utilities is complete before placing higher elevation utilities.

1.8 Quality Assurance

A. Shoring and Sheeting Plan: Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Drawings shall include material sizes and types, arrangement of members, and the sequence and method of installation and removal. Calculations shall include data and references used.

1. The Contractor is required to hire a Professional Geotechnical Engineer to provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer shall be responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions. The Geotechnical Engineer shall update the excavation, sheeting and dewatering plans as construction progresses to reflect changing conditions and shall submit an updated plan if necessary. A written report shall be submitted, at least monthly, informing the Contractor and Owner of the status of the plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems.

B. Dewatering Work Plan: Submit procedures for accomplishing dewatering work.

C. Utilities: Movement of construction machinery and equipment over pipes and utilities during construction shall be at the Contractor's risk. Excavation made with power-driven equipment is not permitted within two feet of known utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Engineer. Report damage to utility lines or subsurface construction immediately to the Engineer.

Part 2 Products

2.1 Soil Materials

A. Satisfactory Materials: Any materials classified by ASTM D2487 as GW, GP, GM, GP-GM, GW-GM, GC,GP-GC, GM-GC, SW, or SP, free of debris, roots, wood, scrap material, vegetation, refuse, soft unsound particles, and frozen, deleterious, or objectionable materials. Unless specified otherwise, the maximum particle diameter shall be one-half the lift thickness at the intended location.

B. Unsatisfactory Materials: Materials which do not comply with the requirements for satisfactory materials. Unsatisfactory materials also include man-made fills, trash, refuse, or backfills from previous construction. Unsatisfactory material also includes material classified as satisfactory which contains root and other organic matter, frozen material, and stones larger than 3 inches. The Engineer shall be notified of any contaminated materials.

C. Backfill and Fill Material: Provide ASTM D2321 materials as listed in Tables 1, 2, and 3.

2.2 Utility Bedding Material

A. Provide ASTM D2321 materials as listed in Tables 1, 2, and 3.

2.3 Borrow

A. Obtain borrow materials required in excess of those furnished from excavations from sources outside of Owner’s property.

2.4 Buried Warning and Identification Tape

A. Warning Tape for Non-metallic Piping: Metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inch minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Color and printing shall be permanent, unaffected by moisture or soil.

Warning Tape Color Codes	
Red:	Electric
Yellow:	Gas, Oil; Dangerous Materials
Orange:	Telephone and Other Communications
Blue:	Potable Water Systems
Green:	Sewer Systems
White:	Steam Systems
Gray:	Compressed Air
Purple:	Non-Potable, Reclaimed Water, Irrigation and Slurry lines

B. Warning Tape for Metallic Piping: Acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above. Minimum thickness of tape shall be 0.003 inch. Tape shall have a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

A. Tracer Wire for Non-Metallic Piping: Tracer wire shall be a #12 AWG (minimum) copper conductor, insulated with a minimum 30 mil, high-density, high molecular weight polyethylene (HDPE) insulation, and rated for direct burial use. HDPE insulation shall be RoHS compliant and utilize virgin grade material.

Part 3 Execution

3.1 Protection

A. Shoring and Sheeting

1. Take special care to avoid damage wherever excavation is being done. Sufficiently sheet, shore, and brace the sides of all excavations to prevent slides, cave-ins, settlement, or movement of the banks and to maintain the specified trench widths. Use solid sheets in wet, saturated, or flowing ground. All sheeting, shoring, and bracing shall have enough strength and rigidity to withstand the pressures exerted, to keep the walls of the excavation properly in place, and to protect all persons and property from injury or damage. Separate payment will not be made for sheeting, shoring, and bracing, which are considered an incidental part of the excavation work.

2. Wherever employees may be exposed to moving ground or cave-ins, shore and lay back exposed earth excavation surfaces more than 5 feet high to a stable slope, or else provide some equivalent means of protection. Effectively protect trenches less than 5 feet deep when examination of the ground indicates hazardous ground movement may be expected. Guard the walls and faces of all excavations in which employees are exposed to danger from moving ground by a shoring system, sloping of the ground, or some equivalent protection.

3. Trench excavation safety protection shall be accomplished as required by the most recent provisions of Part 1926, Subpart P - Excavations, Trenching, and Shoring of the Occupational Safety and Health Administration (OSHA) Standards and Interpretations, as may be amended. Comply with all OSHA standards in determining where and in what manner sheeting, shoring, and bracing are to be done. The sheeting, shoring, and bracing system shall be designed by a professional engineer licensed in the State of Georgia and shall be subject to approval by the Engineer. However, such approval does not relieve the Contractor of the sole responsibility for the safety of all employees, the effectiveness of the system, and any damages or injuries resulting from the lack or inadequacy of sheeting, shoring, and bracing.

4. Where excavations are made adjacent to existing buildings or structures or in paved streets or alleys, take particular care to sheet, shore, and brace the sides of the excavation so as to prevent any undermining of or settlement beneath such structures or pavement. Underpin adjacent structures wherever necessary, with the approval of the Engineer.

5. Do not leave sheeting, shoring, or bracing materials in place unless this is called for by the Drawings, ordered by the Engineer, or deemed necessary or advisable for the safety or protection of the new or existing work or features.

Remove these materials in such a manner that the new structure or any existing structures or property, whether public or private, will not be endangered or damaged and that cave-ins and slides are avoided.

6. Fill and compact all holes and voids left in the work by the removal of sheeting, shoring, or bracing as specified herein.

7. The Contractor may use a trench box, which is a prefabricated movable trench shield composed of steel plates welded to a heavy steel frame. The trench box shall be designed to provide protection equal to or greater than that of an appropriate shoring system.

8. A “Qualified Person”, as defined by OSHA regulations, shall be on-site at all times during activities requiring trench safety provisions.

B. Drainage and Dewatering

1. Provide for the collection and disposal of surface and subsurface water encountered during construction.

2. Drainage: So that construction operations progress successfully, completely drain construction site during periods of construction to keep soil materials sufficiently dry. Where applicable, the Contractor shall establish/construct storm drainage features (ponds/basins) at the earliest stages of site development and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and/or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils, prevent erosion and undermining of foundations. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed. Excavated slopes and backfill surfaces shall be protected to prevent erosion and sloughing. Excavation shall be performed so that the site, the area immediately surrounding the site, and the area affecting operations at the site shall be continually and effectively drained.

3. Dewatering:

   a. Groundwater flowing toward or into excavations shall be controlled to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches will not be permitted within 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Control measures shall be taken by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, the water level shall be maintained continuously, at least 2 feet below the working level.

C. Underground Utilities

   1. Location of the existing utilities indicated is approximate. The Contractor shall physically verify the location and elevation of all existing utilities prior to starting construction.

D. Machinery and Equipment: Movement of construction machinery and equipment over pipes during construction shall be at the Contractor's risk. Repair, or remove and provide new pipe for existing or newly installed pipe that has been displaced or damaged.

3.2 Surface Preparation

A. Identify required lines, levels, contours, and datum.

B. Protect plant life, lawns, and other features remaining as part of final landscaping.

C. Maintain and protect above and below grade utilities which are to remain.

3.3 Excavation

A. Excavate to contours, elevation, and dimensions indicated. Reuse excavated materials that meet the specified requirements for the material type required at the intended location. Keep excavations free from water. Excavate soil disturbed or weakened by Contractor's operations, soils softened or made unsuitable for subsequent construction due to exposure to weather. Excavations below indicated depths will not be permitted except to remove unsatisfactory material.

   1. Blasting: Not allowed.

B. Wherever muck, quicksand, soft clay, swampy ground, or other material unsuitable for foundations, subgrade, or backfilling is encountered, remove it and continue excavation until suitable material is encountered. The material removed shall be disposed of in the manner described below. Then refill the areas excavated for this reason with 1 inch to 2 inch sized crushed stone up to the level of the lines, grades, and/or cross sections shown on the Drawings. The top 6 inches of this refill shall be crushed stone for bedding.

C. Unless specified otherwise, refill excavations cut below indicated depth with satisfactory material and compact to 95 percent of ASTM D698 maximum density. Satisfactory material removed below the depths indicated, without specific direction of the Engineer, shall be replaced with satisfactory materials to the indicated excavation grade. Determination of elevations and measurements of approved overdepth excavation of unsatisfactory material below grades indicated shall be done under the direction of the Engineer.

D. Pipe Trenches:

1. Unless the construction of lines by tunneling, jacking, or boring is called for by the Drawings or specifically authorized by the Engineer, make excavation for pipelines in open cut and true to the lines and grades shown on the Drawings or established by the Engineer on the ground. Cut the banks of trenches between vertical parallel planes equidistant from the pipe centerline. The horizontal distance between the vertical planes (or, if sheeting is used, between the inside faces of that sheeting) shall vary with the size of the pipe to be installed, but shall not be more than the distance determined by the following formula: 4/3d + 15 inches, where "d" represents the internal diameter of the pipe in inches. When approved in writing by the Engineer, the banks of trenches from the ground surface down to a depth not closer than 1 foot above the top of the pipe may be excavated to nonvertical and nonparallel planes, provided the excavation below that depth is made with vertical and parallel sides equidistant from the pipe centerline in accordance with the formula given above. Any cut made in excess of the formula 4/3d + 15 inches shall be at the expense of the Contractor and may be cause for the Engineer to require that stronger pipe and/or a higher class of bedding be used at no cost to the Owner.

2. Grade bottom of trenches to provide uniform support for each section of pipe after pipe bedding placement. Tamp if necessary to provide a firm pipe bed. Recesses shall be excavated to accommodate bells and joints so that the pipe will be uniformly supported for the entire length. Rock, where encountered, shall be excavated to a depth of at least 6 inches below the bottom of the pipe.

3. Excavate bell holes for bell and spigot pipe at proper intervals so that the barrel of the pipe will rest for its entire length upon the bottom of the trench. Bell holes shall be large enough to permit proper jointing of the pipe. Do not excavate bell holes more than 2 joints ahead of pipe laying.

4. Provide minimum depths of “Bedding Material” as defined in Tables 1, 2, and 3.

5. Do not excavate pipe trenches more than 200 feet ahead of the pipe laying, and perform all work so as to cause the least possible inconvenience to the public. Construct temporary bridges or crossings when and where the Engineer deems necessary to maintain vehicular or pedestrian traffic.

6. In all cases where materials are deposited along open trenches, place them so that in the event of rain no damage will result to the work and/or to adjacent property.

E. Hard Material and Rock

1. Any material that is encountered within the limits of the required excavation that cannot be removed except by drilling and/or blasting, including rock, boulders, masonry, hard pan, chert, shale, street and sidewalk pavements, and/or similar materials, shall be considered as unclassified excavation, and no separate payment will be made therefor.

2. Should rock be encountered in the excavation, remove it by blasting or other methods. Where blasts are made, cover the excavation with enough excavation material and/or timber or steel matting to prevent danger to life and property. The Contractor shall secure, at his own expense, all permits required by law for blasting operations and the additional hazard insurance required. Observe all applicable laws and ordinances pertaining to blasting operations.

3. Excavate rock over the horizontal limits of excavation and to a depth of not less than 6 inches below the bottom of pipe up to 30 inches in diameter and not less than 12 inches below the bottom of larger pipes if rock extends to such depth. Then backfill the space below grade with crushed stone or other approved material, tamp to the proper grade, and make ready for construction.

F. Excavated Materials

1. Satisfactory excavated material required for fill or backfill shall be placed in the proper section of the permanent work required or shall be separately stockpiled if it cannot be readily placed. Satisfactory material in excess of that required for the permanent work and all unsatisfactory material shall be disposed of as specified in Paragraph "DISPOSITION OF SURPLUS MATERIAL."

3.4 Filling and Backfilling

A. Fill and backfill to contours, elevations, and dimensions indicated. Compact each lift before placing overlaying lift.

B. Backfill and Fill Material Placement for Utilities

1. Begin backfilling after the line construction is completed and then inspected and approved by the Engineer. Place this backfill simultaneously on either side of the pipe in even layers that before compaction are no more than 6 inches deep. Thoroughly and completely tamp each layer into place before placing additional layers.

C. At locations of improvements subject to damage by displacement, tamp and thoroughly compact the backfill in layers that, before compaction, are 6 inches deep. In other areas, the backfill for the upper portion of the trenches may be placed without tamping but shall be compacted to a density equivalent to that of adjacent earth material as determined by laboratory tests. Use special care to prevent the operation of backfilling equipment from causing any damage to the pipe.

D. If earth material for backfill is, in the opinion of the Engineer, too dry to allow thorough compaction, then add enough water so that the backfill can be properly compacted. Do not place earth material that the Engineer considers too wet or otherwise unsuitable.

E. Wherever excavation has been made within easements across private property, the top 1 foot of backfill material shall consist of topsoil.

F. Wherever trenches have been cut across or along existing pavement and driveways, including gravel or dirt drives, temporarily pave the backfill of such trenches by placing crushed stone as the top 12 inches of the backfill. Maintain this temporary pavement either until the permanent pavement is restored or until the project is accepted by the Owner.

G. Conduct backfilling around manholes, inlets, outfalls, and/or structures in the same manner as specified above for pipelines except that even greater care is necessary to prevent damage to the utility structure.

H. Do not use power operated tampers to tamp that portion of the backfill around the pipe within 1 foot above the pipe.

I. Perform backfilling so as not to disturb or injure any pipe and/or structure against which the backfill is being placed. If any pipe or structure is damaged and/or displaced during backfilling, open up the backfill and make whatever repairs are necessary, whenever directed to do so by the Engineer.

J. Backfilling and clean-up operations shall closely follow pipe laying; failure to comply with this provision will result in the Engineer's requiring that the Contractor's other activities be suspended until backfilling and clean-up operations catch up with pipe laying.

K. Compaction Requirements: Under buildings and 2 times the depth of pipe beyond, and under roads and 2 times the depth beyond the shoulder, compact to 95 percent maximum density in accordance with ASTM D698. In all other locations, compact to 90 percent maximum density.

3.5 Borrow

A. Whenever the backfill of excavated areas or the placement of embankments requires more material than is available from authorized excavations, or whenever the backfill material from such excavations is unsuitable, then obtain additional material from other sources. This may require the opening of borrow pits at points accessible to the work. In such cases, make suitable arrangements with the property owner and pay all incidental costs, including any royalties, for the use of the borrowed material. Before a borrow pit is opened, the quality and suitability of its material shall be approved by the Engineer.

B. Excavate borrow pits in such a way that the remaining surfaces and slopes are reasonably smooth and that adequate drainage is provided over the entire area. Construct drainage ditches wherever necessary to provide outlets for water to the nearest natural channel, thus preventing the formation of pools in the pit area. Leave the sides of borrow pit cuts at a maximum slope of 2:1 unless otherwise directed by the Engineer.

C. Properly clear and grub borrow pits, and remove all objectionable matter from the borrow pit material before placing it in the backfill.

D. The taking of materials from borrow pits for use in the construction of backfill, fills, or embankments shall be considered an incidental part of the work; no separate payment shall be made for this.

3.6 Buried Warning and Identification Tape

A. Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.7 Buried Detection Wire

A. Tape detection wire directly to non-metallic piping. The wire shall extend continuously and unbroken, from manhole to manhole, or valve box to valve box. The ends of the wire shall terminate inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole or valve box. The wire shall remain insulated over its entire length. The wire shall enter manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For water and force mains, the wire shall terminate in a valve pit at the end of the pipe.

3.8 Finish Operations

A. Grading: Finish grades as indicated within one-tenth of one foot. Grade areas to drain water away from structures. Maintain areas free of trash and debris. For existing grades that will remain but which were disturbed by Contractor's operations, grade as directed.

B. Protection of Surfaces: Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

3.9 Disposition of Surplus Material

A. Whenever practicable, all materials removed by excavation that are suitable for backfilling pipe trenches or for other purposes shown on the Drawings or directed by the Engineer shall be used for these purposes. Any materials not so used shall be considered waste materials and disposed of by the Contractor as specified below.

B. Once any part of the work is completed, properly dispose of all surplus or unused materials (including waste materials) left within the construction limits of that work. The Contractor shall dispose of these surplus and waste materials off-site in an appropriate manner in conformity with pertinent codes and ordinances. Leave the surface of the work in a neat and workmanlike condition, as described below.

C. The disposal of waste materials shall be considered an integral part of the excavation work and one for which no separate payment shall be allowed.

3.10 Field Quality Control

A. Sampling: Take the number and size of samples required to perform the following tests.

B. Testing: Perform one of each of the following tests for each material used. Provide additional tests for each source change.

1. Bedding Material and Fill and Backfill Material Testing: Test fill and backfill material in accordance with ASTM C136 for conformance to ASTM D2487 gradation limits; ASTM D1140 for material finer than the No. 200 sieve; ASTM D4318 for liquid limit and for plastic limit; ASTM D698 or ASTM D1557 for moisture density relations, as applicable.

2. Density Tests: Test density in accordance with ASTM D1556, or ASTM D6938. When ASTM D6938 density tests are used, verify density test results by performing an ASTM D1556 density test at a location already ASTM D6938 tested as specified herein. Perform an ASTM D1556 density test at the start of the job, and for every 10 ASTM D6938 density tests thereafter. Test each lift at randomly selected locations with one test per 40 linear feet in each lift.

Table 1: Backfilling and Compaction of Trenches for Pressure Pipes in Unimproved Areas

Layer*	Depth			Material**			
	≤15” Ø	18”-38” Ø	>38” Ø	DIP	PVC	HDPE	Conc
A	4” min	6” min	12” min	I B	II	II	I B
B1	½ OD			III	II	II	III
B2	½ OD			III	II	II	III
C	6”			III	II	II	III
D	6”			IV A	II	II	IV A
E	Varies			IV A	IV A	IV A	IV A
F	12”			As specified in Section 32 92 19			

*See Figure 1.

**Bedding material to be used in wet conditions for all layers.

Table 2: Backfilling and Compaction of Trenches for Gravity Lines in Unimproved Areas

Layer*	Depth			Material**			
	≤15” Ø	18”-38” Ø	>38” Ø	DIP	PVC	HDPE	Conc
A	4” min	6” min	12” min	I B	II	II	I B
B1	½ OD			I B	II	II	I B
B2	½ OD			III	II	II	III
C	6”			III	II	II	III
D	6”			IV A	II	II	IV A
E	Varies			IV A	IV A	IV A	IV A
F	12”			As specified in Section 32 92 19			

*See Figure 1.

**Bedding material to be used in wet conditions for all layers.

Table 3: Backfilling and Compaction of Trenches in Paved Areas

Layer*	**Depth**			**Material**			
	≤15” Ø	18”-38” Ø	>38” Ø	DIP	PVC	HDPE	Conc
A	4” min	6” min	12” min	I B	II	II	I B
B1	½ OD			I B	II	II	I B
B2	½ OD			I B	II	II	I B
C	6”			I B	II	II	I B
D	6”			I B	II	II	I B
E	Varies			I B	II	II	I B
F	12”			As required for pavement base			

*See Figure 1.

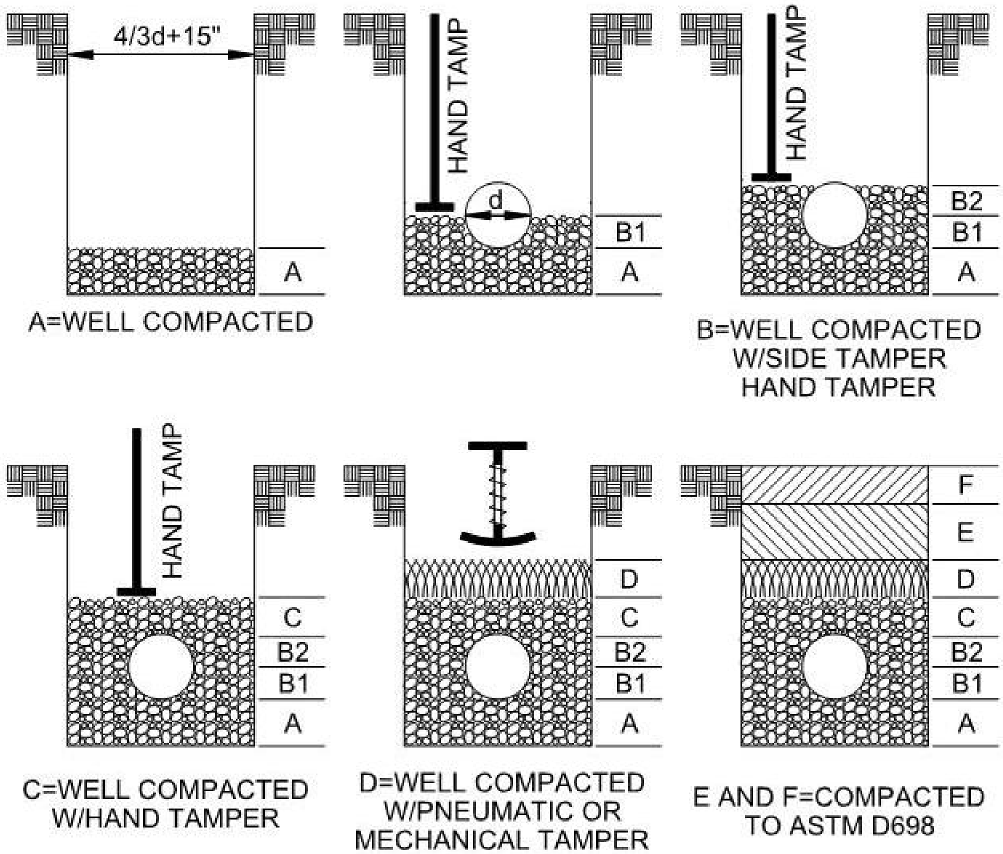

Figure 1: Backfilling and Compaction of Trenches

END OF SECTION

Part 1 General

1.1 Work Included

A. This work shall consist of forming embankments, other than for building pads, with materials from excavation or other approved sources and in conformance with the lines, grades, and cross-section shown on the Drawings.

1.2 Related Sections

A. Section 03 30 00 - Cast-in-Place Concrete: granular course if placed over vapor retarder and beneath the slab-on-grade.

B. Section 31 20 00 – Earth Moving

1.3 Quality Assurance

A. Labor: Use adequate numbers of skilled laborers who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with specified requirements and the methods needed for proper performance of the Work of this section.

B. Equipment: Use equipment adequate in size, capacity, and numbers to accomplish the work of this Section in a timely manner.

C. Codes and Standards: Perform earthwork in compliance with applicable ordinance of governing authorities having jurisdiction.

1. In addition to complying with codes and standards having jurisdiction, comply with the geotechnical engineering report.

2. Conduct all earthwork operations in accordance with the applicable requirements of erosion control as shown on the Drawings and Specifications and as required by local authorities.

D. The Contractor shall provide necessary measures for storm water pollution control and water quality protection. The Contractor shall meet the standards of good housekeeping at all times.

E. Testing and Inspection Services: The Owner will engage a qualified soil testing and inspection service for quality control testing during earthwork operations. Testing shall be performed in accordance with the soil investigation reports and testing standards, the instructions of the Engineer and the applicable sections of General Conditions.

F. Survey: The Contractor shall employ the services of a licensed surveyor for the purposes of survey control, layout, grade and cross-sections required to control work.

1.4 Submittals

A. Conform to provisions of Section 01 33 00.

B. Product Data:

1. Sources of imported materials.

1.5 Temporary Controls

A. Existing Improvements (including trees and shrubs indicated to remain): Protect against damage resulting from Contractor's operations. Repair or replace damaged items to the full satisfaction of the Owner at no added cost to the Owner.

B. Existing Utilities: The Contractor shall locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations.

1. Should uncharted or incorrectly charted piping or other utilities be encountered during earthwork, consult Owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility company.

2. Do not interrupt existing utilities serving facilities occupied and used by Owner and others, except when permitted in writing by the Owner and then only after acceptable temporary utility services have been provided.

3. Provide a minimum of 48-hour notice to Engineer and Owner, and receive written notice to proceed before interrupting any utility.

4. Demolish and completely remove from site existing utilities indicated to be removed. Coordinate with utility companies for shut-off of service if lines are active.

1.6 Delivery, Handling, and Storage

A. Delivery: All materials, tools, equipment, etc. to be delivered to the jobsite in such a manner coordinated with progress of work of this section.

B. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or disposal off-site. Place, grade and shape stockpiles for proper drainage.

1. Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain.

2. Dispose of excess soil material and waste materials as herein specified.

Part 2 Products

2.1 Soil Materials

A. Suitable Excavated Material: Suitable materials from excavations for use in fill and embankments shall be free from shale, sod, large clods or hard lumps of earth, roots, trash or other debris; and is readily compactable to specified density.

B. Fill Material: Furnish imported earth material as necessary; if specified in the contract requirements or if the amount of suitable earth materials obtained from the job-site excavations is not sufficient to properly construct the required fill, subject to the approval of the Engineer prior to use.

1. Obtain imported fill material from a source approved by the Engineer prior to importing to the job-site.

2. Imported fill material shall be free of foreign materials, vegetative growths, sod, rocks, expansive soils and all debris.

C. Use only acceptable materials in embankment formation. Place no frozen material, stumps, logs, roots or other perishable materials in any embankment.

Part 3 Execution

3.1 Surface Conditions

A. Examine the areas and conditions under which the work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until detrimental conditions are corrected.

3.2 Site Preparation

A. Remove the existing soil including fill material, debris, roots and foreign materials to natural soil at the proposed embankment site.

B. Remove topsoil from all embankment areas.

3.3 Embankment Construction

A. Form soil, soft shale, soft sandstone, weathered rock, bank gravel or creek gravel embankment by distributing the material in successive uniform horizontal layers no more than 12 inches thick (loose depth) to the full width of the cross-section. However, layers less than 12 inches in loose thickness will be required whenever necessary to obtain the specified density. Compact each layer as specified below. Shape the upper surface of the embankment so as to provide complete drainage of surface water at all times. The forming of ruts will not be permitted.

B. Do not dump rock into final position, but instead distribute it by blading or dozing in a manner that will ensure proper placement in the embankment so that voids, pockets, and bridging will be reduced to a minimum.

C. In areas where layers of rock and shale or soil are encountered and embankments are constructed of a mixture of rock and shale or rock and soil, place, manipulate and compact the material in layers no more than 8 inches thick; however, when the thickness of the rock exceeds 8 inches, the thickness of the embankment layers may be increased (except beneath building areas) as necessary due to the nature of the material and as approved by a Geotechnical Engineer. In no case allow the layer thickness to exceed 2 feet. Do not dump the mixture into final position but distribute it by blading or dozing in a manner that will ensure proper placement in the embankment so that voids, pockets and bridging will be reduced to a minimum. Then compact the mixture with suitable compaction equipment.

D. Compact the embankment to the following percentage of maximum density as determined by ASTM D698 Standard Proctor.

1. Lawn: 95 percent

2. Pavement: 98 percent

3. Building: 98 percent

E. During compaction, embankment material that does not have enough moisture for proper compaction shall have water added and thoroughly mixed as necessary to obtain proper compaction. Embankment material containing an excess of moisture shall be allowed to dry before compacting; manipulating as necessary to speed drying.

F. Perform construction operations so that simultaneous rolling and placing of material in the same lane or section is prevented. To avoid uneven compaction, see that hauling equipment traverses the full width of the cross-section as much as possible. Compact each layer as necessary before depositing material for the next layer.

G. The density requirements shall be the controlling factor in compaction. Use only such equipment as will satisfy the density requirements at all times.

H. When embankment is placed around adjoining or opposite faces of a structure, compact it to the same level on all sides before proceeding to the next layer. As a precaution against wedging action, begin compaction for each layer next to the structure.

I. Construct embankments adjacent to structures as outlined to the height of the structure and slope far enough away from the structure to permit easy access of compacting equipment used in normal embankment construction.

3.4 Field Quality Control

A. Contractor shall employ a qualified professional geotechnical engineering company to provide testing of embankment construction. The following schedule of testing will be required:

1.	Under Buildings	1 Test Per Lift for Each
2.	Under Roadways and Parking Areas	1 Test Per Lift for Each 5000 Square Feet of Area

B. Written results of these tests shall be made and forward to the Owner's Representative within 2 working days. Any areas failing to meet the required compaction shall be corrected prior to placing the next lift.

END OF SECTION

Part 1 General

1.1 Work Included

A. Preparation of the subgrade, including compacting to the required density and shaping to conform to the required lines, grades, and cross sections.

1.2 Related Sections

A. Section 31 24 00 - Embankments

1.3 Quality Assurance

A. Labor: Use adequate numbers of skilled laborers who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with specified requirements and the methods needed for proper performance of the Work of this section.

B. Equipment: Use equipment adequate in size, capacity, and numbers to accomplish the work of this Section in a timely manner.

C. Codes and Standards: Perform construction of subgrade in compliance with applicable ordinance of governing authorities having jurisdiction.

1. Conduct all operations in accordance with the applicable requirements of erosion control as shown on the Drawings and Specifications and as required by local authorities.

D. The Contractor shall provide necessary measures for storm water pollution control and water quality protection. The Contractor shall meet the standards of good housekeeping at all times.

E. Testing and Inspection Services: The Owner will engage a qualified soil testing and inspection service for quality control testing during earthwork operations. Testing shall be performed in accordance with the soil investigation reports and testing standards, the instructions of the Engineer and the applicable sections of General Conditions.

F. Survey: The Contractor shall employ the services of a licensed surveyor for the purposes of survey control, layout, grade and cross-sections required to control work.

1.4 Submittals

A. Conform to provisions of Section 01 33 00.

B. Product Data:

1. Sources of imported materials.

1.5 Delivery, Handling, and Storage

A. Delivery: All materials, tools, equipment, etc. to be delivered to the job-site, in such a manner coordinated with progress of work of this section.

B. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or dispose off-site. Place, grade and shape stockpiles for proper drainage.

1. Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain.

2. Dispose of excess soil material and waste materials as herein specified.

Part 2 Products

NOT USED

Part 3 Execution

3.1 Subgrade Preparation

A. Proof Rolling: Finish proof rolling on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. The subgrade should be proof rolled with an adequately loaded vehicle such as a fully-loaded tandem-axle dump truck. Proof roll the existing subgrade under the observation of the Geotechnical Engineer or representative. Notify the Engineer a minimum of 3 days prior to proof rolling. Undercut rutting or pumping of material as directed by the Engineer and replace with fill material.

B. All exposed areas which will receive fill, once properly stripped, should be scarified to a minimum depth of 10 inches, moisture conditioned as necessary, and compacted per the compaction requirements in the Geotech report. This is very important on this site due to the loose near surface soils encountered to provide a consistent subgrade across the site. Compacted structural fill soils should then be placed to the proposed design grade and the moisture content and compaction of subgrade soils should be maintained until foundation or pavement construction.

C. Construction

1. Before starting the construction of the base course, pavement, or surface, prepare the subgrade to the full width of the widest course plus 1 foot of additional width beyond each edge, unless otherwise shown on the Drawings.

2. Shape subgrade to line, grade, and cross section, and compact as specified. Include plowing, disking, and any moistening or aerating required to obtain specified compaction for this operation. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Excavate rock encountered in the cut section to

a depth of 6 inches below finished grade for the subgrade. Bring up low areas resulting from removal of unsatisfactory material or excavation of rock to required grade with satisfactory materials, and shape the entire subgrade to line, grade, and cross section and compact as specified. After rolling, the surface of the subgrade for roadways shall not show deviations greater than 1/2 inch when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area. Do not vary the elevation of the finish subgrade more than 0.05 foot from the established grade and cross section.

3. When using a sheepsfoot roller, finish the compaction with either a 3 wheel roller or a multiple wheel, pneumatic tired roller heavy enough to smooth out and compact the indentations made by the sheepsfoot roller.

4. When excess dust is present on the subgrade, either wet it or completely remove and replace with suitable material before placing any aggregate on the subgrade, and do so at no additional cost to the Owner.

5. Operate a grading machine over all subgrades as necessary to maintain a uniform cross section that is free from irregularities. Prepare all subgrades far enough ahead of the base course or pavement construction to permit the necessary testing and checking of the subgrade before any aggregate is placed. Furnish the templates and labor required for checking the subgrade.

6. Complete all ditches and drains in order to drain the subgrade effectively before any construction materials are placed thereon. Take every precaution to protect the subgrade and repair and restore to proper condition all damage that may be caused by the hauling of material or by other causes; place no material on any subgrade until it has been restored and is accepted by the Owner's Representative.

7. Equipment used for hauling materials over the completed subgrade shall be equipped with pneumatic tires. Operate no equipment over the subgrade that is of such weight as to cause rutting.

D. Compaction

1. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Except for paved areas, compact each layer of the embankment to at least 95 percent of laboratory maximum density.

2. Subgrade for Pavements: Compact subgrade for pavements to at least 98 percentage laboratory maximum density for the depth below the surface of the pavement shown.

3. Subgrade for Shoulders: Compact subgrade for shoulders to at least 98 percentage laboratory maximum density for the full depth of the shoulder.

3.2 Shoulder Construction

A. Construct shoulders of satisfactory excavated or borrow material or as otherwise shown or specified. Submit advanced notice on shoulder construction for rigid pavements. Construct shoulders immediately after adjacent paving is complete. In the case of rigid pavements, do not construct shoulders until permission of the Engineer has been obtained. Compact the entire shoulder area to at least the percentage of maximum density as specified in paragraph SUBGRADE PREPARATION above, for specific ranges of depth below the surface of the shoulder. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Finish shoulder construction in proper sequence in such a manner that adjacent ditches will be drained effectively and that no damage of any kind is done to the adjacent completed pavement. Align the completed shoulders true to grade and shaped to drain in conformity with the cross section shown.

3.3 Finishing

A. Finish the surface of subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Finish gutters and ditches in a manner that will result in effective drainage.

B. Subgrade: During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on the finished subgrade.

C. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, or frozen subgrade.

3.4 Testing

A. Determine field in-place density in accordance with ASTM D1556 or ASTM D6938. When ASTM D6938 is used, check the calibration curves and adjust using only the sand cone method as described in ASTM D1556. ASTM D6938 results in a wet unit weight of soil in determining the moisture content of the soil when using this method.

B. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938; check the calibration of both the density and moisture gauges at the beginning of a job on each different type of material encountered and at intervals as directed by the Engineer. When test results indicate that compaction is not as specified, remove the material, replace and recompact to meet specification requirements.

C. Perform tests on recompacted areas to determine conformance with specification requirements. Appoint a registered professional civil engineer to certify inspections and test results. These certifications shall state that the tests and observations were performed by or under the direct supervision of the engineer and that the results are representative of the materials or conditions being certified by the tests. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type operation.

1. Fill and Backfill Material Gradation: One test per 20 cubic yards stockpiled or in-place source material. Determine gradation of fill and backfill material in accordance with ASTM C136.

2. In-Place Densities

    a. One test per 2500 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines.

    b. One test per 2500 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines.

    c. One test per 500 linear feet, or fraction thereof, of each lift of embankment or backfill for roads.

3. Check Tests on In-Place Densities: If ASTM D6938 is used, check in-place densities by ASTM D1556 as follows:

    a. One check test per lift for each 2500 square feet, or fraction thereof, of each lift of fill or backfill compacted by other than hand-operated machines.

    b. One check test per lift for each 2500 square feet, of fill or backfill areas compacted by hand-operated machines.

    c. One check test per lift for each 2500 linear feet, or fraction thereof, of embankment or backfill for roads.

4. Moisture Contents: In the stockpile, excavation, or borrow areas, perform a minimum of two tests per day per type of material or source of material being placed during stable weather conditions. During unstable weather, perform tests as dictated by local conditions and approved by the Engineer.

5. Optimum Moisture and Laboratory Maximum Density: Perform tests for each type material or source of material including borrow material to determine the optimum moisture and laboratory maximum density values. One representative test per 40 cubic yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

6. Tolerance Tests for Subgrades: Perform continuous checks on the degree of finish specified in paragraph SUBGRADE PREPARATION during construction of the subgrades.

END OF SECTION

Part 1 General

1.1 Work Included

A. Aggregate base courses for roadway construction, including materials, placement, and quality control.

1.2 Related Sections

A. Related sections include the following:

1. Section 31 20 00 – Earth Moving

1.3 References

A. Georgia Department of Transportation (GDOT) Standard Specifications for Construction of Transportation Systems.

1.4 Definitions

A. Completed Course: Compacted, unyielding, free from irregularities, with smooth, tight, even surface, true to grade, line, and cross-section.

B. Completed Lift: Compacted with uniform cross-section thickness.

1.5 Submittals

A. Informational Submittals:

1. Certified Test Results on Source Materials: Submit copies from commercial testing laboratory 14 days prior to delivery of materials to Project showing materials meeting the physical qualities specified.

2. Certified results of in-place density tests from independent testing agency.

Part 2 Products

2.1 Base Course

A. Group 1 Graded Aggregate as specified in Section 310 of the Georgia Department of Transportation Standard Specifications for Construction of Transportation Systems.

2.2 Source Quality Control

A. Perform tests necessary to locate acceptable source of materials meeting specified requirements.

B. Final approval of aggregate material will be based on test results of installed materials.

C. Should separation of coarse from fine materials occur during processing or stockpiling, immediately change methods of handling materials to correct uniformity in grading.

Part 3 Execution

3.1 Subgrade Preparation

A. As Specified in Section 31 20 00 – Earth Moving.

B. Obtain Engineer's acceptance of subgrade before placing base course or surfacing material.

C. Do not place base course or surfacing materials on soft, muddy, or frozen subgrade.

3.2 Equipment

A. Compaction Equipment: Adequate in design and number to provide compaction and to obtain specified density for each layer.

3.3 Hauling and Spreading

A. Hauling Materials:

1. Do not haul over surfacing in process of construction.

2. Loads: Of uniform capacity.

3. Maintain consistent gradation of material delivered; loads of widely varying gradations will be cause for rejection.

B. Spreading Materials:

1. Distribute material to provide required density, depth, grade, and dimensions with allowance for subsequent lifts.

2. Produce even distribution of material upon roadway or prepared surface without segregation.

3. Should segregation of coarse from fine materials occur during placing, immediately change methods of handling materials to correct uniformity in grading.

3.4 Construction of Courses

A. Untreated Aggregate Base Course:

1. Maximum Completed Lift Thickness: 6 inches.

2. Completed Course Total Thickness: As shown in the design Drawings.

3. Spread lift on preceding course to required cross-section.

4. Lightly blade and roll surface until thoroughly compacted.

5. Add keystone to achieve compaction and as required when aggregate does not compact readily due to lack of fines or natural cementing properties, as follows:

   a. Spread evenly on top of base course, using spreader boxes or chip spreaders.

   b. Roll surface until keystone is worked into interstices of base course without excessive displacement.

   c. Continue operation until course has become thoroughly keyed, compacted, and will not creep or move under roller.

6. Blade or broom surface to maintain true line, grade, and cross-section.

3.5 Rolling and Compaction

A. Commence compaction of each layer of base after spreading operations and continue until density of 98 percent of maximum density has been achieved as determined by the Standard Proctor Compaction Test in accordance with ASTM D 698.

B. Roll each layer of material until material does not creep under roller before succeeding layer is applied.

C. Commence rolling at outer edges and continue toward center; do not roll center of road first.

D. Apply water as needed to obtain specified densities.

E. Place and compact each lift to required density before succeeding lift is placed.

F. Remove floating or loose stone from surface of preceding course before placing leveling course.

G. Surface Defects: Remedy by loosening and rerolling. Reroll entire area, including surrounding surface, until thoroughly compacted.

H. Finished surface shall be true to grade and crown before proceeding with surfacing.

3.6 Surface Tolerances

A. Blade or otherwise work surfacing as necessary to maintain grade and cross-section at all times, and to keep surface smooth and thoroughly compacted.

B. Finished Surface of Untreated Aggregate Base Course: Within plus or minus 0.04 foot of grade shown at any individual point.

C. Overall Average: Within plus or minus 0.02 foot from crown and grade specified.

3.7 Field Quality Control

A. In-Place Density Tests:

1. Provide Engineer and testing laboratory at least 24 hours advance notification prior to testing.

2. Show proof that areas meet specified requirements before requesting that Engineer identify density test locations.

3. Refer to Table 1 for minimum sampling and testing requirements for aggregate base course and surfacing.

Table 1

Minimum Sampling and Testing Requirements

Property	**Test Method**	**Frequency**	**Sampling Point**
Gradation	Sieve Analysis	One Sample every 500 tons but at least every 4 hours of production	Roadbed after processing
Moisture Density (Maximum Density)	Modified Proctor	One test for every aggregate grading produced	Production output or stockpile
In-place Density and Moisture Content	Nuclear Density Gauge	One for each 500 ton but at least every 10,000 sq ft of area	In-place completed, compacted area

3.8 Cleaning

A. Remove excess material from the Work area. Clean stockpile and staging areas of all excess aggregate.

END OF SECTION

Part 1 General

1.1 Section Includes

A. Small portland cement concrete paving jobs such as access roads, driveways, sidewalks, and parking lots, complete including materials, formwork, and finishing.

1.2 Related Sections

A. 32 11 13 - Subgrade Modifications

B. 32 11 23 - Aggregate Base Courses

1.3 Submittals

A. Submit the following in accordance with Section 01 33 00 Submittal Procedures:

B. Action Submittals:

1. Product Data:

    a. Curing materials

    b. Admixture

    c. Dowels and reinforcement: Submit a complete list of materials including type, brand and applicable reference specifications.

    d. Cementitious materials: Submit documentation indicating percentage of post-industrial and post-consumer recycled content per unit of product. Indicate relative dollar value of recycled content products to total dollar value of products included in project.

2. Design Data:

    a. Concrete Mix Design: Thirty days minimum prior to concrete placement, submit a mix design, with applicable tests, for each strength and type of concrete for approval. Submit a complete list of materials including type; brand; source and amount of cement, fly ash, slag, and admixtures; and applicable reference specifications. Provide mix proportion data using at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required. Submittal shall clearly indicate where each mix design will be used when more than one mix design is submitted. Obtain acknowledgement of approvals prior to concrete placement. Submit a new mix design for each material source change.

C. Informational Submittals

1. Submit copies of laboratory test reports showing that the mix has been successfully tested to produce concrete with the properties specified and that mix will be suitable for the job conditions. The laboratory test reports shall include mill test and all other test for cementitious materials, aggregates, and admixtures. Provide maximum nominal aggregate size, combined aggregate gradation analysis, percentage retained and passing sieve, and a graph of percentage retained verses sieve size. Test reports shall be submitted along with the concrete mix design.

2. Test Reports:

a. Aggregate Tests

b. Concrete Slump Tests

c. Air Content Tests

d. Compressive Strength Tests

e. Certificates

f. Ready-mixed Concrete Plant

g. Batch Tickets

h. Cementitious Materials

D. Field-Constructed Mockup

1. Not Required.

1.4 Delivery, Storage, and Handling

A. In accordance with AASHTO M 157.

1.5 Quality Assurance

A. Ready-mixed Concrete Plant Certification: Unless otherwise approved by the Engineer, ready mixed concrete shall be produced and provided by a National Ready-Mix Concrete Association (NRMCA) certified plant.

B. Contractor Qualifications: Unless waived by the Engineer, the Contractor shall meet one of the following criteria:

1. Contractor shall have at least one National Ready Mixed Concrete Association (NMRCA) certified concrete craftsman and at least one American Concrete Institute (ACI) Flatwork Finisher Certified craftsman on site, overseeing each placement crew during all concrete placement.

2. Contractor shall have no less than three NRMCA certified concrete installers and at least two American Concrete Institute (ACI) Flatwork Finisher Certified installers, who shall be on site working as members of each placement crew during all concrete placement.

C. Sampling and testing of materials, concrete mix design, sampling and testing in the field shall be performed by a commercial testing laboratory which conforms to State DOT requirements.

Part 2 Products

2.1 Materials

A. Cementitious Materials

1. Cementitious materials in concrete mix shall be 20 to 50 percent non-portland cement pozzolanic materials by weight. Substitutions shall be in accordance with applicable state DOT requirements. Provide test data demonstrating compatibility and performance of concrete satisfactory to Engineer.

2. Cement: AASHTO M 85, Type I or II, except that alkali content shall not exceed 0.60 percent.

3. Fly Ash: AASHTO M 295 and complying with state DOT Standard Specifications.

B. Water: Potable water, complying with ASTM C1602.

C. Aggregate:

1. Coarse aggregate shall consist of crushed or uncrushed gravel, crushed stone, or a combination thereof. Aggregates, as delivered to the mixers, shall consist of clean, hard, uncoated particles. Coarse aggregate shall be washed. Washing shall be sufficient to remove dust and other coatings. Coarse aggregate shall conform to state DOT Standard Specifications.

2. Fine aggregate shall consist of natural sand, manufactured sand, or a combination of the two, and shall be composed of clean, hard, durable particles. Fine aggregate shall conform to state DOT Standard Specifications.

3. Both coarse and fine aggregates shall meet the requirements of ASTM C33.

D. Admixtures: In accordance with state DOT Standard Specifications.

E. Reinforcement

1. Dowel Bars: Bars shall conform to AASHTO M 31 for Grade 40 or 60 for plain billet-steel bars of the size and length indicated. Remove all burrs and projections from the bars. The bars shall have a corrosion resistant coating conforming to the requirements of AASHTO M 254 for a Type A or Type B

coating. One end of each dowel used in an expansion assembly shall be provided with an approved tight fitting non-collapsible expansion cap.

2. Tie Bars: Bars shall be billet or axle steel deformed bars and conform to AASHTO M 31 for Grade 40 or 60.

F. Curing Materials

1. White-Burlap-Polyethylene Sheet: AASHTO M 171, 0.004 inch thick white opaque polyethylene bonded to 10 oz./linear yard (40 inch) wide burlap.

2. Liquid Membrane-Forming Compound: AASHTO M 148, Class A, white pigmented, Type 2, Class B, free of paraffin or petroleum.

G. Joint Fillers and Sealants: Provide as specified in state DOT Standard Specifications. New joints shall match existing alignment.

2.2 Concrete Pavement

A. Joint Layout Drawings

1. If jointing requirements on the project drawings are not compatible with the contractor's placement sequence, the contractor shall submit a joint layout plan shop drawing to the Engineer for approval. No work shall be allowed to start until the joint layout plan is approved. The joint layout plan shall indicate and describe in the detail the proposed jointing plan for contraction joints, expansion joints, and construction joints, in accordance with the following:

2. Indicate locations of contraction joints, construction joints, and expansion joints. Spacing between contraction joints shall not exceed 15 feet unless noted otherwise or approved by the Engineer.

3. The larger dimension of a panel shall not be greater than 125% of the smaller dimension.

4. The minimum angle between two intersecting joints shall be 80 degrees, unless noted otherwise or approved by the Engineer.

5. Joints shall intersect pavement-free edges at a 90 degree angle to the pavement edge and shall extend straight for a minimum of 1.5 feet from the pavement edge, where possible.

6. Align joints of adjacent panels.

7. Align joints in attached curbs with joints in pavement when possible. Ensure joint depth, widths, and dimensions are specified.

8. Minimum contraction joint depth shall be 1/4 of the pavement thickness. The minimum joint width shall be 1/8 inch.

9. Use expansion joints only where pavement abuts buildings, foundations, manholes, and other fixed objects.

2.3 Contractor-furnished Mix Design

A. Contractor-furnished mix design concrete shall be designed in accordance with state DOT requirements except as modified herein, and the mix design shall be as specified herein. The concrete shall have a minimum compressive strength of 4000 pounds per square inch at 28 days. The concrete may be air entrained. If air entrainment is used the air content shall be between 2.5 and 6.0 percent. Maximum size aggregate for slip forming shall be 1.5 inches. The slump shall be 2 inches or less. For slip-formed pavement, at the start of the project, select a maximum allowable slump which will produce in-place pavement meeting the specified tolerances for control of edge slump.

Part 3 Execution

3.1 Forms

A. Construction: Construct forms to be removable without damaging the concrete.

B. Coating: Before placing the concrete, coat the contact surfaces of forms with a non-staining mineral oil, non-staining form coating compound, or two coats of nitro-cellulose lacquer. When using existing pavement as a form, clean existing concrete and then coat with asphalt emulsion bondbreaker before concrete is placed.

C. Grade and Alignment: Check and correct grade elevations and alignment of the forms immediately before placing the concrete.

3.2 Reinforcement

A. Dowel Bars

1. Install bars accurately aligned, vertically and horizontally, at indicated locations and to the dimensions and tolerances indicated. Before installation thoroughly grease the sliding portion of each dowel. Dowels must remain in position during concrete placement and curing.

B. Tie Bars

1. Install bars, accurately aligned horizontally and vertically, at indicated locations.

C. Setting Slab Reinforcement

1. Reinforcement shall be positioned on suitable chairs prior to concrete placement. At expansion, contraction and construction joints, place the reinforcement as indicated. Reinforcement, when placed in concrete, shall be free of mud, oil, scale or other foreign materials. Place reinforcement accurately

and wire securely. The laps at splices shall be 12 inches minimum and the distances from ends and sides of slabs and joints shall be as indicated.

3.3 Measuring, Mixing, Conveying, and Placing Concrete

A. Measuring: AASHTO M 157.

B. Mixing: AASHTO M 157, except as modified herein. Begin mixing within 30 minutes after cement has been added to aggregates. When the air temperature is greater than 85 degrees F, place concrete within 60 minutes.

C. Conveying: AASHTO M 157.

D. Placing: Follow guidance of ACI 301, except as modified herein. Do not exceed a free vertical drop of 5 feet from the point of discharge. Deposit concrete either directly from the transporting equipment or by conveyor on to the pre-wetted subgrade or subbase, unless otherwise specified. Do not place concrete on frozen subgrade or subbase. Deposit the concrete between the forms to an approximately uniform height. Place concrete continuously at a uniform rate, with minimum amount of segregation, without damage to the grade and without unscheduled stops except for equipment failure or other emergencies. If this occurs within 10 feet of a previously placed expansion joint, remove concrete back to joint, repair any damage to grade, install a construction joint and continue placing concrete only after cause of the stop has been corrected.

E. Vibration

1. Immediately after spreading concrete, consolidate concrete with internal type vibrating equipment along the boundaries of all slabs regardless of slab thickness, and interior of all concrete slabs 6 inches or more in thickness. Limit duration of vibration to that necessary to produce consolidation of concrete. Excessive vibration will not be permitted. Vibrators shall not be operated in concrete at one location for more than 15 seconds. At the option of the Contractor, vibrating equipment of a type approved by the Engineer may be used to consolidate concrete in unreinforced pavement slabs less than 6 inches thick.

2. Vibrating Equipment: Operate equipment, except hand-manipulated equipment, ahead of the finishing machine. Select the number of vibrating units and power of each unit to properly consolidate the concrete. Mount units on a frame that is capable of vertical movement and, when necessary, radial movement, so vibrators may be operated at any desired depth within the slab or be completely withdrawn from the concrete. Clear distance between frame-mounted vibrating units that have spuds that extend into the slab at intervals across the paving lane shall not exceed 30 inches. Distance between end of vibrating tube and side form shall not exceed 2 inches. For pavements less than 10 inches thick, operate vibrators at mid-depth parallel with or at a slight angle to the subbase. For thicker pavements, angle vibrators toward the vertical, with vibrator tip preferably about 2 inches from subbase, and top of vibrator a few mm inches below pavement surface. Vibrators may be pneumatic, gas driven, or electric, and shall be operated at frequencies within

the concrete of not less than 8,000 vibrations per minute. Amplitude of vibration shall be such that noticeable vibrations occur at 1.5 foot radius when the vibrator is inserted in the concrete to the depth specified.

F. Cold Weather: Except with authorization, do not place concrete when ambient temperature is below 40 degrees F or when concrete is likely to be subjected to freezing temperatures within 72 hours. When authorized, when concrete is likely to be subjected to freezing within 72 hours after placing, heat concrete materials so that temperature of concrete when deposited is between 65 and 80 degrees F. Methods of heating materials are subject to approval of the Engineer. Do not heat mixing water above 165 degrees F. Remove lumps of frozen material and ice from aggregates before placing aggregates in mixer. Follow practices found in ACI 306.1.

G. Hot Weather: If there is a possibility that ambient temperatures will be above 90 degrees F during the placement of the concrete, conduct operations in accordance with state DOT Standard Specifications.

3.4 Paving

A. Underlying layer shall be preconditioned prior to placement of concrete in accordance with state DOT Standard Specifications.

B. Pavement shall be constructed with paving and finishing equipment utilizing fixed forms.

C. Consolidation: The paver vibrators shall be inserted into the concrete not closer to the underlying material than 2 inches. The vibrators or any tamping units in front of the paver shall be automatically controlled so that they shall be stopped immediately as forward motion ceases. Excessive vibration shall not be permitted. Concrete in small, odd-shaped slabs or in locations inaccessible to the paver mounted vibration equipment shall be vibrated with a hand-operated immersion vibrator. Vibrators shall not be used to transport or spread the concrete.

D. Operation: When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provisions shall be made to prevent damage to the previously constructed pavement, including keeping the existing pavement surface free of any debris, and placing rubber mats beneath the paver tracks. Transversely oscillating screeds and extrusion plates shall overlap the existing pavement the minimum possible, but in no case more than 8 inches.

E. Required Results: The paver-finisher shall be operated to produce a thoroughly consolidated slab throughout, true to line and grade within specified tolerances. The paver-finishing operation shall produce a surface finish free of irregularities, tears, voids of any kind, and any other discontinuities. It shall produce only a very minimum of paste at the surface. Multiple passes of the paver-finisher shall not be permitted. The equipment and its operation shall produce a finished surface requiring no hand finishing, other than the use of cutting straightedges, except in very infrequent instances. No water, other than true fog sprays (mist), shall be applied to the concrete surface during paving and finishing.

F. Fixed Form Paving: Forms shall be steel, except that wood forms may be used for curves having a radius of 150 feet or less, and for fillets. Forms may be built up with metal or wood, added only to the base, to provide an increase in depth of not more than 25 percent. The base width of the form shall be not less than eight-tenths of the vertical height of the form, except that forms 8 inches or less in vertical height shall have a base width not less than the vertical height of the form. Wood forms for curves and fillets shall be adequate in strength and rigidly braced. Forms shall be set on firm material cut true to grade so that each form section when placed will be firmly in contact with the underlying layer for its entire base. Forms shall not be set on blocks or on built-up spots of underlying material. Forms for overlay pavements and for other locations where forms must be set on existing pavements shall be held securely in place with stakes or by other approved methods. Holes in existing pavements for form stakes shall be carefully drilled without cracking or spalling the existing pavement. Prior to setting forms for paving operations, the Contractor shall demonstrate the proposed form setting procedures at an approved location and shall not proceed further until the proposed method is approved. Forms shall remain in place at least 12 hours after the concrete has been placed. Forms shall be removed without injuring the concrete.

G. Slip-form Paving: The slipform paver shall shape the concrete to the specified and indicated cross section in one pass, and shall finish the surface and edges so that only a very minimum amount of hand finishing is required. Dowels shall not be installed by dowel inserters attached to the paver or by any other means of inserting the dowels into the plastic concrete.

H. Placing Dowels and Tie Bars

1. Dowels shall be installed with alignment not greater than 1/8 inch per ft. Except as otherwise specified below, location of dowels shall be within a horizontal tolerance of plus or minus 5/8 inch and a vertical tolerance of plus or minus 3/16 inch. The portion of each dowel intended to move within the concrete or expansion cap shall be painted with one coat of rust inhibiting primer paint, and then oiled just prior to placement. Dowels and tie bars in joints shall be omitted when the center of the dowel is located within a horizontal distance from an intersecting joint equal to or less than one-fourth of the slab thickness.

2. Contraction Joints: Dowels and tie bars in longitudinal and transverse contraction joints within the paving lane shall be held securely in place by means of rigid metal basket assemblies. The dowels and tie bars shall be welded to the assembly or held firmly by mechanical locking arrangements that will prevent them from becoming distorted during paving operations. The basket assemblies shall be held securely in the proper location by means of suitable anchors.

3. Construction Joints-Fixed Form Paving: Installation of dowels shall be by the bonded-in-place method, supported by means of devices fastened to the forms. Installation by removing and replacing in preformed holes will not be permitted.

4. Dowels Installed in Hardened Concrete: Installation shall be by bonding the dowels into holes drilled into the hardened concrete. Holes approximately 1/8 inch greater in diameter than the dowels shall be drilled into the hardened

concrete. Dowels shall be bonded in the drilled holes using epoxy resin injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel shall not be permitted. The dowels shall be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic collar fitted around the dowel. The vertical alignment of the dowels shall be checked by placing the straightedge on the surface of the pavement over the top of the dowel and measuring the vertical distance between the straightedge and the beginning and ending point of the exposed part of the dowel.

5. Expansion Joints: Dowels in expansion joints shall be installed by the bonded-in-place method or by bonding into holes drilled in hardened concrete, using procedures specified above.

3.5 Finishing Concrete

A. Start finishing operations immediately after placement and consolidation of concrete. Use finishing machine, except hand finishing may be used in emergencies and for concrete slabs in inaccessible locations or of such shapes or sizes that machine finishing is impracticable. Finish pavement surface on both sides of a joint to the same grade. Finish formed joints from a securely supported transverse bridge. Provide hand finishing equipment for use at all times. Transverse and longitudinal surface tolerances shall be 1/4 inch in 10 feet.

B. Side Form Finishing: Strike off and screed concrete to the required slope and cross-section by a power-driven transverse finishing machine. Transverse rotating tube or pipe shall not be permitted unless approved by the Engineer. Elevation of concrete shall be such that, when consolidated and finished, pavement surface will be adequately consolidated and at the required grade. Equip finishing machine with two screeds which are readily and accurately adjustable for changes in pavement slope and compensation for wear and other causes. Make as many passes over each area of pavement and at such intervals as necessary to give proper compaction, retention of coarse aggregate near the finished surface, and a surface of uniform texture, true to grade and slope. Do not permit excessive operation over an area, which will result in an excess of mortar and water being brought to the surface.

1. Equipment Operation: Maintain the travel of machine on the forms without lifting, wobbling, or other variation of the machine which tend to affect the precision of concrete finish. Keep the tops of the forms clean by a device attached to the machine. During the first pass of the finishing machine, maintain a uniform ridge of concrete ahead of the front screed for its entire length.

2. Joint Finish: Before concrete is hardened, correct edge slump of pavement, exclusive of edge rounding, in excess of ¼ inch. Finish concrete surface on each side of construction joints to the same plane, and correct deviations before newly placed concrete has hardened.

C. Hand Finishing: Strike-off and screed surface of concrete to elevations slightly above finish grade so that when concrete is consolidated and finished pavement surface is at the indicated elevation. Vibrate entire surface until required compaction and reduction of surface voids is secured with a strike-off template.

D. Longitudinal Floating: After initial finishing, further smooth and consolidate concrete by means of hand-operated longitudinal floats. Use floats that are not less than 12 feet long and 6 inches wide and stiffened to prevent flexing and warping.

E. Texturing

1. Before the surface sheen has disappeared and before the concrete hardens, the surface of the pavement shall be given a texture as described herein. Following initial texturing on the first day of placement, the Placing Foreman, Engineer’s representative, and a representative of the Owner shall inspect the texturing for compliance with design requirements. After curing is complete, all textured surfaces shall be thoroughly power broomed to remove all debris. The concrete in areas of recesses for tie-down anchors, lighting fixtures, and other outlets in the pavement shall be finished to provide a surface of the same texture as the surrounding area.

2. Brooming: Finish the surface of the slab by brooming the surface with a new wire broom at least 18 inches wide. Gently pull the broom over the surface of the pavement from edge to edge just before the concrete becomes non-plastic. Slightly overlap adjacent strokes of the broom. Broom perpendicular to centerline of pavement so that corrugations produced will be uniform in character and width, and not more than 1/16 inch in depth. Broomed surface shall be free from porous spots, irregularities, depressions, and small pockets or rough spots such as may be caused by accidentally disturbing particles of coarse aggregate embedded near the surface.

F. Edging: At the time the concrete has attained a degree of hardness suitable for edging, carefully finish slab edges, including edges at formed joints, with an edge having a maximum radius of one-eighth inch. When brooming is specified for the final surface finish, edge transverse joints before starting brooming, then operate broom to obliterate as much as possible the mark left by the edging tool without disturbing the rounded corner left by the edger. Clean by removing loose fragments and soupy mortar from corners or edges of slabs which have crumbled and areas which lack sufficient mortar for proper finishing. Refill voids solidly with a mixture of suitable proportions and consistency and refinish. Remove unnecessary tool marks and edges. Remaining edges shall be smooth and true to line.

G. Repair of Surface Defects Follow guidance of ACI 301.

3.6 Curing and Protection

A. Protect concrete adequately from injurious action by sun, rain, flowing water, mechanical injury, tire marks and oil stains, and do not allow it to dry out from the time it is placed until the expiration of the minimum curing periods specified herein. Use White-Burlap-Polyethylene Sheet or liquid membrane-forming compound, except as specified otherwise herein. Do not use membrane-forming compound on surfaces where its appearance would be objectionable, on surfaces to be painted, where coverings are to be bonded to concrete, or on concrete to which other concrete is to be bonded. Maintain temperature of air next to concrete above 40 degrees F for the full curing periods.

B. White-Burlap-Polyethylene Sheet: Wet entire exposed surface thoroughly with a fine spray of water, saturate burlap but do not have excessive water dripping off the burlap and then cover concrete with White-Burlap-Polyethylene Sheet, burlap side down. Lay sheets directly on concrete surface and overlap 12 inches. Make sheeting not less than 18 inches wider than concrete surface to be cured, and weight down on the edges and over the transverse laps to form closed joints. Repair or replace sheets when damaged during curing. Check daily to assure burlap has not lost all moisture. If moisture evaporates, resaturate burlap and re-place on pavement (re-saturation and re-placing shall take no longer than 10 minutes per sheet). Leave sheeting on concrete surface to be cured for at least 7 days.

C. Liquid Membrane-Forming Compound Curing: Apply compound immediately after surface loses its water sheen and has a dull appearance and before joints are sawed. Agitate curing compound continuously by mechanical means during use and apply uniformly in a two-coat continuous operation by suitable power-spraying equipment. Total coverage for the two coats shall be at least one gallon of undiluted compound per 100 square feet. Compound shall form a uniform, continuous, coherent film that will not check, crack, or peel and shall be free from pinholes or other imperfections. Apply an additional coat of compound immediately to areas where film is defective. Respray concrete surfaces that are subject to heavy rainfall within 3 hours after curing compound has been applied in the same manner.

D. Protection of Treated Surfaces: Keep concrete surfaces to which liquid membrane-forming compounds have been applied free from vehicular traffic and other sources of abrasion for not less than 72 hours. Foot traffic is allowed after 24 hours for inspection purposes. Maintain continuity of coating for entire curing period and repair damage to coating immediately.

3.7 Field Quality Control

A. Sampling: The Contractor's approved laboratory shall collect samples of fresh concrete in accordance with AASHTO T 141 during each working day as required to perform tests specified herein. Make test specimens in accordance with AASHTO T 23.

B. Consistency Tests: The Contractor's approved laboratory shall perform concrete slump tests in accordance with AASHTO T 119. Take samples for slump determination from concrete during placement. Perform tests at the beginning of a concrete placement operation and for each batch (minimum) or every 50 cubic yards (maximum) of concrete to ensure that specification requirements are met. In addition, perform tests each time test beams and cylinders are made.

C. Compressive Strength Tests: The Contractor's approved laboratory shall test for compressive strength in accordance with AASHTO T 22. Make four test specimens for each set of tests. Test two specimens at 14 days, and the other two at 28 days. Concrete strength will be considered satisfactory when the minimum of the 28-day test results equals or exceeds the specified 28-day compressive strength, and no individual strength test is less than 3000 pounds per square inch. Concrete which is determined to be defective, based on the strength acceptance criteria therein, shall be removed and replaced with acceptable concrete.

D. Air Content Tests: Test air-entrained concrete for air content at the same frequency as specified for slump tests. Determine percentage of air in accordance with AASHTO T 152 on samples taken during placement of concrete in forms.

E. Surface Testing

1. Surface testing for surface smoothness and plan grade shall be performed as indicated below by the Testing Laboratory. The measurements shall be properly referenced in accordance with paving lane identification and stationing, and a report given to the Owner within 24 hours after measurement is made. A final report of surface testing, signed by a Registered Engineer, containing all surface measurements and a description of all actions taken to correct deficiencies, shall be provided to the Owner upon conclusion of surface testing.

2. Surface Smoothness Requirements: Surface smoothness shall be measured every 120 square feet. The finished surfaces of the pavements shall have no abrupt change of 1/8 inch or more, and all pavements shall be within the tolerances specified when checked as below:

a. 1/4 inch longitudinal from a 16 foot straightedge.

b. 1/4 inch with a 10 foot straightedge when measured perpendicular to the centerline.

c. 3/8 inch in any 25 foot section from a taut string applied parallel to the surface.

3. Plan Grade Testing and Conformance:

a. The surfaces shall vary not more than ½ inch in 100 feet from designated grade.

b. The surfaces shall not vary by more than 0.20% from the required cross slope in any 10 foot distance.

F. Test for Pavement Thickness: Full depth cores in accordance with AASHTO T 24 shall be taken a minimum of every 250 square feet to measure thickness.

G. Reinforcement: Inspect reinforcement prior to installation to assure it is free of loose flaky rust, loose scale, oil, mud, or other objectionable material.

H. Dowels: Inspect dowel placement prior to placing concrete to assure that dowels are of the size indicated, and are spaced, aligned and painted and oiled as specified. Dowels shall not deviate from vertical or horizontal alignment after concrete has been placed by more than 1/8 inch per foot.

3.8 Waste Management

A. In accordance with the Waste Management Plan.

END OF SECTION

Part 1 General

1.1 Work Included

A. Concrete sidewalks

B. Concrete curbs and gutters

1.2 Basis for Payment

A. Sidewalks: Payment of the quantities of sidewalks measured as specified will be at the contract unit price per square yard of the thickness specified.

1.3 System Description

A. General Requirements

1. Provide plant, equipment, machines, and tools used in the work subject to approval and maintained in a satisfactory working condition at all times. The equipment shall have the capability of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified.

2. Use of the equipment shall be discontinued if it produces unsatisfactory results.

3. The Engineer shall have access at all times to the plant and equipment to ensure proper operation and compliance with specifications.

B. Slip Form Equipment: Slip form paver or curb forming machine, will be approved based on trial use on the job and shall be self-propelled, automatically controlled, crawler mounted, and capable of spreading, consolidating, and shaping the plastic concrete to the desired cross section in one pass.

1.4 Submittals

A. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

B. Submit manufacturer/supplier certifications for aggregate and cement. Provide the project identification name and number, date of report, name of Contractor, name of concrete testing service, source of concrete aggregates, materials manufacturer and brand name for manufactured materials, values specified in the referenced specification for each material, and test results.

C. Submit mix design in accordance with ACI requirements. Provide for each mix design, the project name, city, general contractor, concrete strength, and its intended use.

D. Submit 2 copies of laboratory test reports with standard deviation analysis or trial batch data. All concrete materials shall be listed.

1.5 Environmental Requirements

A. Placing During Cold Weather

1. Do not place concrete when the air temperature reaches 40 degrees F and is falling or is already below that point.

2. Placement may begin when the air temperature reaches 35 degrees F and is rising, or is already above 40 degrees F. Make provisions to protect the concrete from freezing during the specified curing period.

3. If necessary to place concrete when the temperature of the air, aggregates, or water is below 35 degrees F, placement and protection shall be approved in writing. Approval will be contingent upon full conformance with the following provisions.

4. The underlying material shall be prepared and protected so that it is entirely free of frost when the concrete is deposited.

5. Mixing water and aggregates shall be heated as necessary to result in the temperature of the in-place concrete being between 50- and 85-degrees F. Methods and equipment for heating shall be approved.

6. The aggregates shall be free of ice, snow, and frozen lumps before entering the mixer.

7. Covering and other means shall be provided for maintaining the concrete at a temperature of at least 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period.

B. Placing During Warm Weather

1. The temperature of the concrete as placed shall not exceed 85 degrees F except where an approved retarder is used. The mixing water and/or aggregates shall be cooled, if necessary, to maintain a satisfactory placing temperature. The placing temperature shall not exceed 95 degrees F at any time.

Part 2 Products

2.1 Concrete

A. Provide concrete conforming to the applicable requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE except as otherwise specified. Concrete shall have a minimum compressive strength of 3000 psi at 28 days. Maximum size of aggregate shall be one inch. Submit copies of certified delivery tickets for all concrete used in the construction.

B. Air Content

1. Mixtures shall have air content by volume of concrete of 5 to 7 percent, based on measurements made immediately after discharge from the mixer.

C. Slump

1. The concrete slump shall be 2 inches plus or minus 1 inch where determined in accordance with ASTM C143.

D. Reinforcement Steel

1. Reinforcement bars shall conform to ASTM A615. Wire mesh reinforcement shall conform to ASTM A1064.

2.2 Concrete Curing Materials

A. Impervious Sheet Materials: Impervious sheet materials shall conform to ASTM C171, type optional, except that polyethylene film, if used, shall be white opaque.

B. Burlap: Burlap shall conform to AASHTO M 182.

C. White Pigmented Membrane-Forming Curing Compound: White pigmented membrane-forming curing compound shall conform to ASTM C309, Type 2.

2.3 Concrete Protection Materials

A. Concrete protection materials shall be a linseed oil mixture of equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the Contractor, commercially prepared linseed oil mixtures, formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used, except that emulsified mixtures are not acceptable.

2.4 Joint Filler Strips

A. Contraction Joint Filler for Curb and Gutter: Contraction joint filler for curb and gutter shall consist of hard-pressed fiberboard.

B. Expansion Joint Filler, Pre-molded

1. Expansion joint filler, pre-molded, shall conform to ASTM D1751 or ASTM D1752, 1/2 inch thick, unless otherwise indicated.

2.5 Joint Sealants

A. Joint sealant, cold-applied shall conform to ASTM C920 or ASTM D5893.

2.6 Form Work

A. Design and construct form work to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified.

B. Forms shall be of wood or steel, straight, of sufficient strength to resist springing during depositing and consolidating concrete.

1. Wood forms shall be surfaced plank, 2 inches nominal thickness, straight and free from warp, twist, loose knots, splits or other defects.

   a. Wood forms shall have a nominal length of 10 feet.

   b. Radius bends may be formed with 3/4-inch boards, laminated to the required thickness.

2. Steel forms shall be channel-formed sections with a flat top surface and with welded braces at each end and at not less than two intermediate points.

   a. Ends of steel forms shall be interlocking and self-aligning.

   b. Steel forms shall include flexible forms for radius forming, corner forms, form spreaders, and fillers.

   c. Steel forms shall have a nominal length of 10 feet with a minimum of 3 welded stake pockets per form. Stake pins shall be solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

C. Sidewalk Forms: Sidewalk forms shall be of a height equal to the full depth of the finished sidewalk.

D. Curb and Gutter Forms: Curb and gutter outside forms shall have a height equal to the full depth of the curb or gutter. The inside form of curb shall have batter as indicated and shall be securely fastened to and supported by the outside form.

1. Rigid forms shall be provided for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 10 feet or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used.

2. Back forms for curb returns may be made of 1-1/2 inch benders, for the full height of the curb, cleated together.

3. In lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

Part 3 Execution

3.1 Subgrade Preparation

A. The subgrade shall be constructed to the specified grade and cross section prior to concrete placement.

B. Subgrade shall be placed and compacted in conformance with Section 32 11 13.

C. Sidewalk Subgrade: The subgrade shall be tested for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

D. Curb and Gutter Subgrade: The subgrade shall be tested for grade and cross section by means of a template extending the full width of the curb and gutter. The subgrade shall be of materials equal in bearing quality to the subgrade under the adjacent pavement.

E. Maintenance of Subgrade: The subgrade shall be maintained in a smooth, compacted condition in conformity with the required section and established grade until the concrete is placed. The subgrade shall be in a moist condition when concrete is placed. The subgrade shall be prepared and protected to produce a subgrade free from frost when the concrete is deposited.

3.2 Form Setting

A. Set forms to the indicated alignment, grade and dimensions.

B. Hold forms rigidly in place by a minimum of 3 stakes per form placed at intervals not to exceed 4 feet.

1. Corners, deep sections, and radius bends shall have additional stakes and braces, as required.

2. Clamps, spreaders, and braces shall be used where required to ensure rigidity in the forms.

C. Forms shall be removed without injuring the concrete.

1. Bars or heavy tools shall not be used against the concrete in removing the forms.

D. Any concrete found defective after form removal shall be promptly and satisfactorily repaired.

E. Forms shall be cleaned and coated with form oil each time before concrete is placed.

1. Wood forms may, instead, be thoroughly wetted with water before concrete is placed, except that with probable freezing temperatures, oiling is mandatory.

F. Sidewalks

1. Set forms for sidewalks with the upper edge true to line and grade with an allowable tolerance of 1/4 inch in any 10 foot long section.

2. After forms are set, grade and alignment shall be checked with a 10-foot straightedge.

3. Forms shall have a transverse slope as indicated with the low side adjacent to the roadway. Side forms shall not be removed for 12 hours after finishing has been completed.

G. Curbs and Gutters

1. The forms of the front of the curb shall be removed not less than 2 hours nor more than 6 hours after the concrete has been placed.

2. Forms back of curb shall remain in place until the face and top of the curb have been finished, as specified for concrete finishing.

3. Gutter forms shall not be removed while the concrete is sufficiently plastic to slump in any direction.

3.3 Sidewalk Concrete Placement and Finishing

A. Formed Sidewalks

1. Place concrete in the forms in one layer. When consolidated and finished, the sidewalks shall be of the thickness indicated.

2. After concrete has been placed in the forms, a strike-off guided by side forms shall be used to bring the surface to proper section to be compacted.

3. The concrete shall be consolidated by tamping and spading or with an approved vibrator, and the surface shall be finished to grade with a strike off.

B. Concrete Finishing

1. After straightedging, when most of the water sheen has disappeared, and just before the concrete hardens, finish the surface with a wood or magnesium float or darby to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. A scored surface shall be produced by brooming with a fiber-bristle brush in a direction transverse to that of the traffic, followed by edging.

2. Edge and Joint Finishing:

a. All slab edges, including those at formed joints, shall be finished with an edger having a radius of 1/8 inch.

b. Transverse joint shall be edged before brooming, and the brooming shall eliminate the flat surface left by the surface face of the edger.

c. Corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing shall be cleaned and filled solidly with a properly proportioned mortar mixture and then finished.

C. Surface and Thickness Tolerances: Finished surfaces shall not vary more than 5/16 inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to 1/4 inch.

3.4 Curb and Gutter Concrete Placement and Finishing

A. Formed Curb and Gutter: Concrete shall be placed to the section required in a single lift. Consolidation shall be achieved by using approved mechanical vibrators. Curve shaped gutters shall be finished with a standard curb "mule".

B. Curb and Gutter Finishing: Approved slip-formed curb and gutter machines may be used in lieu of hand placement.

C. Concrete Finishing

1. Exposed surfaces shall be floated and finished with a smooth wood float until true to grade and section and uniform in texture. Floated surfaces shall then be brushed with a fine-hair brush with longitudinal strokes.

2. The edges of the gutter and top of the curb shall be rounded with an edging tool to a radius of 1/2 inch.

3. Immediately after removing the front curb form, the face of the curb shall be rubbed with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. The front curb surface, while still wet, shall be brushed in the same manner as the gutter and curb top.

4. The top surface of gutter and entrance shall be finished to grade with a wood float.

5. Joint Finishing: Curb edges at formed joints shall be finished as indicated.

D. Surface and Thickness Tolerances: Finished surfaces shall not vary more than 1/4 inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to 1/4 inch.

3.5 Sidewalk Joints

A. Sidewalk joints shall be constructed to divide the surface into rectangular areas.

1. Transverse contraction joints shall be spaced at a distance equal to the sidewalk width or 5 feet on centers, whichever is less, and shall be continuous across the slab.

2. Longitudinal contraction joints shall be constructed along the centerline of all sidewalks 10 feet or more in width.

3. Transverse expansion joints shall be installed at sidewalk returns and opposite expansion joints in adjoining curbs.

4. Where the sidewalk is not in contact with the curb, transverse expansion joints shall be installed as indicated.

B. Expansion joints shall be formed about structures and features which project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated.

1. Expansion joints are not required between sidewalks and curb that abut the sidewalk longitudinally.

C. Sidewalk Contraction Joints: The contraction joints shall be formed in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness, using a jointer to cut the groove, or by sawing a groove in the hardened concrete with a power-driven saw, unless otherwise approved.

1. Sawed joints shall be constructed by sawing a groove in the concrete with a 1/8-inch blade to the depth indicated.

2. An ample supply of saw blades shall be available on the job before concrete placement is started, and at least one standby sawing unit in good working order shall be available at the jobsite at all times during the sawing operations.

D. Sidewalk Expansion Joints

1. Expansion joints shall be formed with 1/2-inch joint filler strips. Joint filler in expansion joints surrounding structures and features within the sidewalk may consist of preformed filler material conforming to ASTM D1752 or building paper.

2. Joint filler shall be held in place with steel pins or other devices to prevent warping of the filler during floating and finishing.

3. Immediately after finishing operations are completed, joint edges shall be rounded with an edging tool having a radius of 1/8 inch, and concrete over the joint filler shall be removed.

4. At the end of the curing period, expansion joints shall be cleaned and filled with cold-applied joint sealant.

5. Joint sealant shall be gray or stone in color.

6. The joint opening shall be thoroughly cleaned before the sealing material is placed.

7. Sealing material shall not be spilled on exposed surfaces of the concrete.

8. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 50 degrees F at the time of application of joint sealing material.

9. Excess material on exposed surfaces of the concrete shall be removed immediately and concrete surfaces cleaned.

E. Reinforcement Steel Placement

1. Reinforcement steel shall be accurately and securely fastened in place with suitable supports and ties before the concrete is placed.

3.6 Curb and Gutter Joints

A. Curb and gutter joints shall be constructed at right angles to the line of curb and gutter.

B. Contraction Joints

1. Contraction joints shall be constructed directly opposite contraction joints in abutting Portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 5 feet nor greater than 15 feet in length.

2. Contraction joints (except for slip forming) shall be constructed by means of 1/8 inch thick separators and of a section conforming to the cross section of the curb and gutter. Separators shall be removed as soon as practicable after concrete has set sufficiently to preserve the width and shape of the joint and prior to finishing.

3. When slip forming is used, the contraction joints shall be cut in the top portion of the gutter/curb hardened concrete in a continuous cut across the curb and gutter, using a power-driven saw. The depth of cut shall be at least one-fourth of the gutter/curb depth and 1/8 inch in width.

C. Expansion Joints

1. Expansion joints shall be formed by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Expansion joints shall be provided in curb and gutter directly opposite expansion joints of abutting Portland cement concrete pavement and shall be of the same type and thickness as joints in the pavement.

2. Where curb and gutter do not abut Portland cement concrete pavement, expansion joints at least 1/2 inch in width shall be provided at intervals not less than 30 feet nor greater than 120 feet.

3. Expansion joints shall be provided in nonreinforced concrete gutter at locations indicated.

4. Expansion joints shall be sealed immediately following curing of the concrete or as soon thereafter as weather conditions permit.

5. Expansion joints and the top 1-inch depth of curb and gutter contraction-joints shall be sealed with joint sealant.

6. The joint opening shall be thoroughly cleaned before the sealing material is placed.

7. Sealing material shall not be spilled on exposed surfaces of the concrete.

8. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 50 degrees F at the time of application of joint sealing material.

9. Excess material on exposed surfaces of the concrete shall be removed immediately and concrete surfaces cleaned.

3.7 Curing and Protection

A. General Requirements

1. Protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation.

2. Protect unhardened concrete from rain and flowing water.

3. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready for use before actual concrete placement begins.

4. Protection shall be provided as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

B. Mat Method

1. The entire exposed surface shall be covered with 2 or more layers of burlap.

2. Mats shall overlap each other at least 12 inches.

3. The mat shall be thoroughly wetted with water prior to placing on concrete surface and shall be kept continuously in a saturated condition and in intimate contact with concrete for not less than 72 hours.

C. Impervious Sheeting Method

1. The entire exposed surface shall be wetted with a fine spray of water and then covered with impervious sheeting material.

2. Sheets shall be laid directly on the concrete surface with the light-colored side up and overlapped 12 inches when a continuous sheet is not used.

3. The curing medium shall not be less than 18-inches wider than the concrete surface to be cured and shall be securely weighted down by heavy wood planks, or a bank of moist earth placed along edges and laps in the sheets.

4. Sheets shall be satisfactorily repaired or replaced if torn or otherwise damaged during curing.

5. The curing medium shall remain on the concrete surface to be cured for not less than 72 hours.

D. Membrane Curing Method

1. A uniform coating of white-pigmented membrane-curing compound shall be applied to the entire exposed surface of the concrete as soon after finishing as the free water has disappeared from the finished surface. Formed surfaces shall be coated immediately after the forms are removed and in no case longer than 1 hour after the removal of forms.

2. Concrete shall not be allowed to dry before the application of the membrane. If any drying has occurred, the surface of the concrete shall be moistened with a fine spray of water and the curing compound applied as soon as the free water disappears.

3. Curing compound shall be applied in two coats by hand-operated pressure sprayers at a coverage rate of approximately 200 square feet/gallon for the total of both coats.

4. The second coat shall be applied in a direction approximately at right angles to the direction of application of the first coat.

5. The compound shall form a uniform, continuous, coherent film that will not check, crack, or peel and shall be free from pinholes or other imperfections. If pinholes, abrasion, or other discontinuities exist, an additional coat shall be applied to the affected areas within 30 minutes.

6. Concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied shall be resprayed by the method and at the coverage specified above.

7. Areas where the curing compound is damaged by subsequent construction operations within the curing period shall be resprayed.

8. Necessary precautions shall be taken to ensure that the concrete is properly cured at sawed joints, and that no curing compound enters the joints.

9. The top of the joint opening and the joint groove at exposed edges shall be tightly sealed before the concrete in the region of the joint is resprayed with curing compound. The method used for sealing the joint groove shall prevent loss of moisture from the joint during the entire specified curing period.

10. Approved standby facilities for curing concrete pavement shall be provided at a location accessible to the jobsite for use in the event of mechanical failure of the spraying equipment or other conditions that might prevent correct application of the membrane-curing compound at the proper time.

11. Concrete surfaces to which membrane-curing compounds have been applied shall be adequately protected during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane.

3.8 Backfilling

A. After curing, debris shall be removed and the area adjoining the concrete shall be backfilled, graded, and compacted to conform to the surrounding area in accordance with lines and grades indicated.

3.9 Protection

A. Completed concrete shall be protected from damage until accepted.

B. Repair damaged concrete and clean concrete discolored during construction. Concrete that is damaged shall be removed and reconstructed for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Removed damaged portions shall be disposed of as directed.

C. Protective Coating

1. Protective coating, of linseed oil mixture, shall be applied to the exposed-to-view concrete surface after the curing period, if concrete will be exposed to de-icing chemicals within 6 weeks after placement.

2. Concrete to receive a protective coating shall be moist cured.

3. Application

a. Curing and backfilling operation shall be completed prior to applying two coats of protective coating.

b. Concrete shall be surface dry and clean before each application.

c. Coverage shall be by spray application at not more than 50 square yards/gallon for first application and not more than 70 square yards/gallon for second application, except that the number of applications and coverage for each application for commercially prepared mixture shall be in accordance with the manufacturer's instructions.

d. Coated surfaces shall be protected from vehicular and pedestrian traffic until dry.

4. Precautions

   a. Protective coating shall not be heated by direct application of flame or electrical heaters and shall be protected from exposure to open flame, sparks, and fire adjacent to open containers or applicators.

   b. Material shall not be applied at ambient or material temperatures lower than 50 degrees F.

3.10 Field Quality Control

A. Submit copies of all test reports within 24 hours of completion of the test.

B. General Requirements

   1. Perform the inspection and tests described and meet the specified requirements for inspection details and frequency of testing.

   2. Based upon the results of these inspections and tests, take the action and submit reports as required below, and any additional tests to ensure that the requirements of these specifications are met.

C. Concrete Testing

   1. Strength Testing: Provide molded concrete specimens for strength tests. Samples of concrete placed each day shall be taken not less than once a day nor less than once for every 250 cubic yards of concrete. The samples for strength tests shall be taken in accordance with ASTM C172. Cylinders for acceptance shall be molded in conformance with ASTM C31 by an approved testing laboratory. Each strength test result shall be the average of 2 test cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved. Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, and no individual strength test result falls below the specified strength by more than 500 psi.

   2. Air Content: Determine air content in accordance with ASTM C173 or ASTM C231. ASTM C231 shall be used with concretes and mortars made with relatively dense natural aggregates. Two tests for air content shall be made on randomly selected batches of each class of concrete placed during each shift. Additional tests shall be made when excessive variation in concrete workability is reported by the placing foreman or the Owner's inspector. If results are out of tolerance, the placing foreman shall be notified, and he shall take appropriate action to have the air content corrected at the plant. Additional tests for air content will be performed on each truckload of material until such time as the air content is within the tolerance specified.

   3. Slump Test: Two slump tests shall be made on randomly selected batches of each class of concrete for every 250 cubic yards, or fraction thereof, of concrete placed during each shift. Additional tests shall be performed when excessive

variation in the workability of the concrete is noted or when excessive crumbling or slumping is noted along the edges of slip-formed concrete.

4. Thickness Evaluation: The anticipated thickness of the concrete shall be determined prior to placement by passing a template through the formed section or by measuring the depth of opening of the extrusion template of the curb forming machine. If a slip form paver is used for sidewalk placement, the subgrade shall be true to grade prior to concrete placement and the thickness will be determined by measuring each edge of the completed slab.

5. Surface Evaluation: The finished surface of each category of the completed work shall be uniform in color and free of blemishes and form or tool marks.

3.11 Surface Deficiencies and Corrections

A. Thickness Deficiency: When measurements indicate that the completed concrete section is deficient in thickness by more than 1/4 inch the deficient section will be removed, between regularly scheduled joints, and replaced.

B. High Areas: In areas not meeting surface smoothness and plan grade requirements, high areas shall be reduced either by rubbing the freshly finished concrete with carborundum brick and water when the concrete is less than 36 hours old or by grinding the hardened concrete with an approved surface grinding machine after the concrete is 36 hours old or more. The area corrected by grinding the surface of the hardened concrete shall not exceed 5 percent of the area of any integral slab, and the depth of grinding shall not exceed 1/4 inch. Areas requiring grade or surface smoothness corrections in excess of the limits specified above shall be removed and replaced.

C. Appearance: Exposed surfaces of the finished work will be inspected by the Owner and any deficiencies in appearance will be identified. Areas which exhibit excessive cracking, discoloration, form marks, or tool marks or which are otherwise inconsistent with the overall appearances of the work shall be removed and replaced.

END OF SECTION

Part 1 General

1.1 Section Includes

A. Ductile Iron Couplings

B. Fabricated Steel Couplings

C. Flange Adapter Couplings

D. Dismantling Joints

1.2 Related Sections

A. Section 40 05 51 – Common Requirements for Process Valves

B. Section 40 23 00 – Water and Wastewater Process Piping

1.3 Submittals

A. Submit under provisions of Section 01 33 00.

B. Product Data: Provide data on materials, operational components, and accessories. Submit manufacturer's descriptive and technical literature for each component, including design recommendations; pressure and temperature ratings; dimensions; and chemical resistance to each chemical and chemical mixture in the liquid stream.

C. Operations and Maintenance Data: Submit under provisions of Section 01 78 23. Provide manuals for all operational devices.

Part 2 Products

2.1 Materials and Equipment

A. Piping specialties, appurtenances, and equipment supplied as part of this contract shall be of equal material and ratings as the connecting pipe, new and unused except for testing equipment.

B. Components that serve the same function and are the same size shall be identical products of the same manufacturer.

C. Pipe fittings shall be compatible with the applicable pipe materials.

D. Standard Products

1. Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacturing of the products and that

essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.2 Ductile Iron Couplings (DI CPLG)

A. Ductile iron couplings for use in connecting smooth end joints of cast iron, ductile iron, asbestos cement, steel, PVC or other types of pipe must be capable of fitting this variety of pipes with one set of follower flanges or end rings.

B. Sleeve shall be of Ductile Iron ASTM A536. Ends shall have a smooth inside taper to provide uniform gasket seal. Sleeve shall be given a shop coat of oil–modified urethanes, corrosion-resistant paint, or epoxy coating.

C. Follower flanges or end rings shall be of the thickness determined by the coupling size, and shall be ductile iron, ASTM-536. Flanges shall be identified by a color-coded shop coat finish.

D. Gaskets shall be compression – type, formed with Virgin Styrene Butadiene Rubber (SBR,) ASTM D2000 3 BA715, and compounded with ingredients to produce permanence and resistance to set after installation. O.D. range shall be imprinted/molded on the gasket in permanent ink (Minimum.)

E. Bolts and Nuts shall be of high-strength, low-alloy steel, with nominal coarse thread, and hex nuts with black finish.

F. Dimensions and minimum stress values shall be in accordance with AWWA/ANSI C111/A21.11.

G. Manufacturers and Products:

1. Smith-Blair, Inc. 441

2. JCM Industries 210

3. Romac Industries, Inc. 501

2.3 Fabricated Steel Couplings (FAB CPLG)

A. Sleeve-Type Couplings, 1 inch through 48 inches

1. Sleeve-type couplings shall be used for joining plain end pipe sections in a flexible manner with a diameter to properly fit the pipe. Coupling shall be suitable for pipe size and material, with stiffeners provided for HDPE pipe. Couplings shall comply with AWWA C219. Materials shall be as follows:

a. Sleeve: ASTM A53, ASTM A513 or Carbon Steel having minimum yield of 30,000 PSI.

b. Followers: Steel AISI C 1020, or A715 Grade 80 HSLA Steel. Design for a high strength-to-weight ratio. Follower thickness determined by coupling size.

c. Bolts & Nuts: Stainless steel

d. Gasket: Nitrile (Buna N) NSF 61 compounded to produce superior storage and performance characteristics while resisting water, acids, alkalis, most (aliphatic) hydrocarbon fluids, and other chemicals for a temperature range of -20°F to 180°F.

e. Finish: Fusion Bonded Epoxy Finish

2. Working Pressure: Up to 150 PSI

3. Manufacturers/Models

a. Smith-Blair, Inc. 411

b. JCM Industries 201

c. Romac Industries, Inc. 400

B. Transition Couplings:

1. Transitional couplings may be used to connect two pipes that have small differences in outside diameter. A fully assembled transitional coupling shall be sized to properly fit pipe diameters. Couplings shall comply with AWWA C219. Materials shall be as follows:

a. Sleeve: ASTM A53, ASTM A513 or Carbon Steel having minimum yield of 30,000 PSI.

b. Followers: Ductile Iron ASTM A536, or Steel AISI C 1020. Design for a high strength-to-weight ratio. Follower thickness determined by coupling size.

c. Bolts & Nuts: [High strength, low alloy Steel][Stainless steel] with heavy semi-finished hexagon nuts.

d. Gasket: Nitrile (Buna N) NSF 61 compounded to produce superior storage and performance characteristics while resisting water, acids, alkalis, most (aliphatic) hydrocarbon fluids, and other chemicals for a temperature range of -20°F to 180°F.

e. Finish: Fusion Bonded Epoxy Finish

2. Working Pressure: Up to 150 PSI

3. Manufacturers/Models

a. Smith-Blair, Inc. 413.

b. JCM Industries 203

c. Or Approved Equal.

2.4 Isolation Joints

A. Dielectric Fittings: Dielectric fittings shall be provided between threaded ferrous and nonferrous metallic pipe, fittings and valves. Dielectric fittings shall prevent metal-to-metal contact of dissimilar metallic piping elements and shall be suitable for the required working pressure, temperature and corrosive application.

B. Isolation Joints: Isolation joints shall be provided between nonthreaded ferrous and nonferrous metallic pipe fittings and valves. Isolation joints shall consist of an isolation gasket of the dielectric type, isolation washers and isolation sleeves for flange bolts. Isolation gaskets shall be full-faced with an outside diameter equal to the flange outside diameter. Bolt isolation sleeves shall be full length. Units shall be of a shape to prevent metal-to-metal contact of dissimilar metallic piping elements.

2.5 Flange Coupling Adapters (FCA)

A. Flange coupling adapters shall be of the size and pressure rating required for each installation and shall be suitable for use on the pipe to be connected.

B. All couplings shall have a sufficient number of factory installed anchor devices to meet or exceed the test pressure rating for this project, or 300 psi minimum.

C. Sleeve shall be of A36, A283 Gr. C, or Carbon Steel having a minimum yield of 30,000 PSI. Ends shall have a smooth inside taper to provide uniform gasket seal. Sleeve shall be given a shop coat of oil–modified urethanes, corrosion-resistant paint, or epoxy coating.

D. Flanges shall be flat face flanges complying with AWWA C207 Class D, ANSI 150 lb. drilling.

E. Gland shall be 65-45-12 Ductile Iron (ASTM A536) and shall be coated with the same material as the sleeve. MJ gaskets shall be standard SBR gaskets complying with AWWA C111 and ANSI A21. 11.

F. Bolts and Nuts shall be of high-strength, low-alloy steel, per AWWA C111.

G. Dimensions and minimum stress values shall be in accordance with AWWA/ANSI C111/A21.11.

H. Manufacturers and Products:

1. Smith Blair, Style 911
2. Romac Industries, Inc. RFCA
3. Approved Equal

2.6 Dismantling Joints (Restrained) (DMJ)

A. Restrained dismantling joint fittings shall meet the specifications set forth in AWWA C219, be of the size and pressure rating required for each installation and shall be suitable for use on the pipe to be connected. Restrained dismantling joint fittings shall have a sufficient number of factory installed bolts and tie rods to meet or exceed the test pressure rating for this project, or 150 psi minimum.

B. Followers for 3” through 12” shall be Ductile Iron 65-45-12 per ASTM A536; for size 14” and larger shall be Carbon Steel C1020 per ASTM A576. Sleeve and spool weldment material shall be Carbon Steel per ASTM A283C. Flanges shall meet AWWA C207 Class D Steel Ring Flange, compatible with ANSI Class 125 and 150 bolt circles. Total angular deflection up to 1-1/2° per joint. Bolts, nuts and tie rods shall be Type 304 stainless steel. Fittings shall have a fusion bonded epoxy finish which meets application methods AWWA C213.

C. Gaskets shall be Nitrile (Buna-N) per ASTM D2000, NSF/ANSI 61 and 372 certified and compounded to resist water, oil, natural gas, acids, alkalis, most (aliphatic) hydrocarbon fluids, and many other chemicals. Temperature range: -20ºF to +180ºF.

D. Manufacturers and Products:

1. Smith Blair, Model 975

2. Romac Industries, Style DJ400

3. Or Approved Equal

2.7 Service Saddles

A. Saddle casting or body for pipe up to sixteen-inch nominal size shall be of the double strap/bale or double and single band type with minimum four studs/bolts on the single band type. Casting shall be cast bronze of the size and application specified. Material shall be in accordance with ASTM B62 and B584 (85-5-5-5) requirements and fabricated to ANCI/AWWAC800, latest revision. Saddles for PVC pipe shall be pre-formed to AWWA C900 and C905 outside diameter dimensions and so stamped or otherwise identified by a permanent inked marking that will not smear or wash off on the body of the saddle. C900 formed saddles may be used on ductile iron pipe from sizes four through sixteen inches.

B. Saddle casting or body for ductile iron, cast iron and C900 pipe in sizes above sixteen-inch (16”) shall be ductile iron and shall be of the double or triple band stainless steel type of the size and application specified. Material shall be in accordance with ASTM A-536 requirements and fabricated to ANCI/ AWWA C800, latest revision. The saddle casting or body shall be coated with a fusion-bonded epoxy or high density polyethylene. The body shall be NSF 61 approved. The coating shall be NSF 61 or U.L approved to the NSF 61 standard.

C. The minimum width for double stainless steel bands on 16 inch and larger pipe diameters shall measure two inches each. The minimum width for single stainless bands shall measure four inches (4").

D. The minimum gauge of the stainless steel bands shall be eighteen gauge. In order to prevent deformation, the minimum gauge of the stainless steel side bars shall be ten gauge. All welds shall be fully passivated for enhanced corrosion resistance.

E. The bolts/studs shall be 5/8" UNC roll thread with heavy gauge flat hex nuts. All Stainless nuts shall be coated to prevent galling.

F. Gaskets shall be virgin rubber, NSF 61 approved, meet ASTM D-2000 and be NBR or SBR compounded to produce permanence and resistance to set after installation and deterioration during storage.

G. Quality control procedures shall be employed to ensure that the bronze saddle casting, straps (bronze bale or stainless steel band), and gasket are manufactured to be free of any visible defects. Each saddle shall have a working pressure rating not less than the following:

Pipe Size (inches)	Minimum Working Pressure Rating (psi)
12 and smaller	175
16 and larger	150

Part 3 Execution

3.1 Examination

A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

3.2 Preparation

A. Protection: Pipe and equipment openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.

B. System Preparation

1. Provide accessibility to piping specialties for control and maintenance.

3.3 Manufacturer's Field Services

A. Obtain manufacturer's technical assistance for Contractor training, installation inspection, start up, and owner operating and maintenance training.

B. Follow manufacturer's instructions for installation.

C. Metallic Piping Couplings: Thrust ties shall be provided where shown on the contract drawings and where required to restrain the force developed by 1.5 times the maximum allowable operating pressures specified. For metallic pipe other than ductile iron, thrust ties shall be attached with fabricated lugs. For ductile iron pipe, thrust ties shall be attached with socket clamps against a grooved joint coupling or flange. For exposed installations, zinc-plated nuts and bolts shall be used. However, high-strength, low-alloy steel, in accordance with AWWA C111/A21.11, may be substituted for use on cast iron and ductile iron couplings. For buried and submerged installations, TP304 stainless steel bolts and nuts shall be provided. Steel middle rings and followers shall be fusion bonded epoxy-lined and coated in accordance with Section 09 90 15 - Paint and pressure tested beyond yield point.

D. Sleeve-Type Couplings: Sleeve-type couplings shall be used for joining plain end pipe sections in a flexible manner with a diameter to properly fit the pipe.

E. Transition Couplings: Transitional couplings may be used to connect two pipes of the same material that have small differences in outside diameter. A fully assembled transitional coupling shall be sized to properly fit pipe diameters.

END OF SECTION

Part 1 General

1.1 Work Included

A. Furnish and install the following:

1. Pipe Hangers
2. Pipe Supports
3. Concrete Inserts
4. Anchor Bolts
5. Cable Trays, Metallic and Non-Metallic.

1.2 Submittals

A. Submit in accordance with Section 01 33 00.

B. Product Data:

1. Provide product data for each type of pipe hanger or support required.
2. Submit manufacturer's data on cable tray including, but not limited to, types, materials, finishes, rung spacing, inside depths and fitting radii. For side rails and rungs, submit cross sectional properties including Section Modulus (Sx) and Moment of Inertia (Ix).

C. Shop Drawings:

1. Indicate locations and mounting heights of each type of hardware.
2. Submit manufacturer’s templates and installation instructions.
3. Submit drawings of cable tray and accessories including clamps, brackets, hanger rods, splice plate connectors, expansion joint assemblies, and fittings, showing accurately scaled components.

1.3 Quality Assurance

A. Piping support systems shall be designed and Shop Drawings prepared and sealed by a Professional Engineer registered in the state where the Work is to be installed.

B. Steel pipe hangers and supports shall have the manufacturer’s name, part number, and applicable size stamped in the part itself for identification.

C. All materials used in manufacturing hangers and supports shall be capable of meeting the respective ASTM standard specifications with regard to tests of physical and chemical properties and be in accordance with MSS SP-58.

1.4 Design Requirements

A. General:

1. Hangers and supports shall be of manufacturer's standard design and shall be adequate to maintain the supported load in proper position under all operating conditions. Meet requirements of MSS SP58 and ASME B31.1 or as modified by this Section.

2. Design, size and locate piping support systems throughout the facility, regardless of whether shown or not.

3. Supports are shown only where specific types and locations are required; additional pipe supports may be required.

B. Pipe Support Systems:

1. Design pipe support systems for gravity and thrust loads imposed by weight of pipes and internal pressures, including insulation and weight of fluid in pipes.

2. Wind loads in accordance with governing Codes [and as shown on the Structural Drawings].

3. [Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.]

4. Maximum support spacing and minimum rod size: In accordance with MSS SP58, Table 3 and 4, excerpts of which follow below:

Nominal Pipe Size (inches)	Maximum Spacing (feet)
½ to 1-1/4	5
1-1/2	7.5
2	10
3-4	12
6-8	15
Over 8	20

a. Ductile iron pipe 8 inches and smaller: Maximum span limited to that for standard weight steel pipe for water service with a minimum of one support per pipe section at the joints.

b. Ductile iron pipe 10 inches and larger: Maximum span limited to 20 feet with a minimum of one support per pipe section at the joints.

c. Supports for multiple plastic pipes shall be continuous wherever possible. Individually supported plastic pipes shall be supported as recommended by the manufacturer, except that the support spacing shall not exceed five (5) feet.

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

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

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

F. All pipe and appurtenances connected to equipment shall be supported in such a manner as to prevent any strain being imposed on the equipment. When manufacturers have indicated requirements that piping loads shall not be transmitted to their equipment, the Contractor shall submit a certification stating that such requirements have been complied with.

1.5 Coordination

A. Coordinate work under provisions of Section 01 33 00 and Section 01 61 00.

B. Coordinate work with installation of process piping, piping insulation, and valves.

1.6 Delivery, Storage, and Handling

A. Deliver, store, protect, and handle products to site under provisions of Section 01 66 00.

B. Deliver items in their original factory shipping cartons.

Part 2 Products

2.1 General

A. Verify that field measurements are as instructed by the manufacturer.

B. Manufacturer: Unless otherwise specified herein, pipe hangers and supports shall be as manufactured by Cooper B-Line, Inc. or engineer approved equal. Any reference to a specific figure number or a specific manufacturer is for the purpose of establishing a type and quality of product and shall not be considered as proprietary. Any item equal in type, style, quality, design and performance will be considered for approval.

2.2 Hangers

A. Clevis: MSS SP58, Type 1:

1. Cooper B-Line B3100 for steel pipe and B3102 for ductile iron pipe, ½-inch through 30 inches.

2. Anvil Figure 260 with insulated saddle system (ISS) for insulated steel pipe, ½- inch through 16 inches for insulated steel pipe.

B. Adjustable Swivel Split-Ring Pipe Clamp: MSS SP58, Type 6:

1. Cooper B-Line Figure B3171, sizes ¾-inch through 8 inches.

2. Anvil Figure 104, sizes ¾-inch through 8 inches.

2.3 Wall Brackets, Supports and Guides

A. Welded Steel Wall Brackets, MSS SP58, Type 33 (Heavy Duty):

1. Cooper B-Line Figures B3065, B3066, and B3067 as required, for pipe sizes up to and including 20 inches. Additional wall bearing plates shall be provided where required.

B. Adjustable “J” Hanger, MSS SP58, Type 5

1. Cooper B-Line Figure B3690 for sizes ½ inch through 8 inches.

2. Anvil Figure 67 for sizes ½ inch through 8 inches.

C. Offset Pipe Clamp:

1. Cooper B-Line B3148 for sizes ½” through 12 inches.

2.4 Pipe Saddles

A. Saddle Supports, Pedestal Type:

1. Minimum standard weight pipe stanchion, saddle, and anchoring flange. Pipe stanchion shall be galvanized or carbon steel, except that supports located in corrosive areas shall be 304 stainless steel.

2. Non-adjustable saddle: MSS SP58, Type 37 with U-bolt:

a. Cooper B-Line Figure B3095 for sizes 1 inch through 36 inches with B3088S base.

3. Adjustable pipe saddle: MSS SP58, Type 38 without clamp:

a. Cooper B-Line Figure B3092 for sizes ¾ inch through 36 inches with B3088S base.

2.5 Channel Type Support Systems

A. Channel Size: 12 gauge, 1-5/8 wide minimum steel, except that supports located in corrosive areas shall be 304 stainless steel or fiberglass.

B. Members and Connections: Design for loads using one-half of manufacturer's allowable loads.

C. Fasteners: Vinyl ester fiber, polyurethane base composite nuts and bolts or encapsulated steel fasteners.

2.6 Pipe Clamps

A. Riser Clamp: MSS SP58, Type 8

1. Cooper B-Line Figure B3373 for sizes ½ inch through 30 inches.

2. Anvil Figure 261 for sizes ¾ inch through 24 inches.

2.7 Elbow and Flange Supports

A. Elbow with Adjustable Stanchion:

1. Anvil Figure 62C Base for sizes 2 inches through 18 inches.

B. Elbow with Non-adjustable Stanchion:

1. Anvil Figure 63A or 63B Base for sizes 2-1/2 inches through 42 inches.

C. Flange Support with Adjustable Base:

1. Standon Model S89, for sizes 2 inches through 24 inches.

2.8 Intermediate Pipe Guides

A. Hold Down Pipe Guide:

1. Cooper B-Line Figure B3552 for sizes 1-1/2 inches through 30 inches.

B. U-Bolts, with double nuts to provide nominal 1/8 inch to ¼ inch clearance around pipe; MSS SP58, Type 24

1. Cooper B-Line Figure B3188 and B3188NS

2. Anvil Figure 137 and 137S.

2.9 Pipe Anchors

A. Anchor Chair with U-bolt Strap

1. Cooper B-Line Figure B3147A or Figure B3147B.

2.10 Restraints

A. Solid pipe bracing attachment to pipe clevis with clevis cross brace and angle rod reinforcement.

2.11 Accessories

A. Anchor Bolts:

1. Size and Material: Sized by Contractor for required loads, ½ inch minimum diameter, and as specified in Division 5.

2. Bolt Length (Extension above top of nut):

a. Minimum length: Flush with top of nut.

b. Maximum length: No more than a full nut depth above the top of nut.

B. Dielectric Barriers:

1. Plastic coated hangers, isolation cushion, or tape.

2. Cooper B-Line Figure B1999 Vibra Cushion.

3. Cooper B-Line Iso-Pipe or Iso-Tape.

C. Insulation Shields, MSS SP58, Type 40

1. Galvanized or stainless steel.

2. Cooper B-Line Figure B3151 for sizes ½ inch through 24 inches.

D. Welding Insulation Saddles, MSS SP58, Type 39

1. Cooper B-Line Figure B3160 for sizes ½ inch through 24 inches.

E. Hanger Rods: Hanger rods shall be machine threaded with load ratings conforming to ASTM Specifications and the strength of the rod based on rod diameter. Rods shall be 304 or 316 stainless steel in corrosive areas and galvanized in other areas. Hanger rods shall have the following minimum diameters:

Pipe Diameter (in.)	Rod Diameter (in.)
Less than 2-1/2	3/8
2-1/2 up to 4	½
4	5/8
6	¾
8 through 12	7/8
14 through 18	1
20 through 30	1-1/2

F. Clevises, Nuts, Sockets and Turnbuckles: In accordance with MSS SP58.

G. Attachments:

1. Beam Clamps: Where applicable, beam clamps shall be used to suspend piping from building steel. Clamp type shall be selected on the basis of load to be supported, and load configuration.

a. C-Clamps shall have locknuts and cup point set screws, B-Line B351L, or B3036L. Top flange c-clamps shall be used when attaching a hanger rod to the top flange of structural shapes, B-Line B3034 or B3033. Refer to manufacturer's recommendation for setscrew torque. Retaining straps shall be used to maintain the clamps position on the beam where required.

b. Center loaded beam clamps shall be used where specified. Steel clamps shall be B-Line B3050, or B3055. Malleable iron or forged steel beam clamps with cross bolt shall be B-Line B3054 or B3291-B3297 Series as required to fit beams.

2. Concrete Insert: MSS SP58, Type 18, continuous channel insert with load rating not less than that of hanger rod it supports.

3. Welded Beam Attachment: MSS SP58, Type 22

a. Cooper B-Line Figure B3083

4. Concrete Attachment Plates

a. Cooper B-Line Figures B3084, B3085 or B3086.

2.12 Finishes

A. Outdoor and Corrosive Area Finishes

1. All hanger hardware shall be hot dip galvanized or stainless steel. Zinc plated hardware is not acceptable for outdoor or corrosive use. Hangers and struts shall be hot dip galvanized after fabrication in accordance with ASTM A123.

2. Hangers and strut located in corrosive areas, including chemical feed and storage areas, shall be type 316 stainless steel with stainless steel hardware or non-metallic with non-metallic hardware.

Part 3 Execution

3.1 Inspection

A. Verify that surfaces are ready to receive work and dimensions are as instructed by the manufacturer and required to provide proper support.

B. Beginning of installation means acceptance of existing conditions.

3.2 Installation

A. General

1. All pipes, horizontal and vertical, shall be adequately supported from the building structure by pipe hanger and supports specified in Part 2 - Products. Install support systems in accordance with MSS SP58, unless shown otherwise.

2. Install pipe hanger rods plumb, within 4 degrees of vertical during startup, shutdown, or operations.

3. Pipe supports shall be provided to minimize lateral forces through valves, both sides of split type couplings and sleeve type couplings, and to minimize all pipe forces at pump housings. Pump housings shall not be utilized to support connecting pipes.

4. Support large or heavy valves, fittings, and appurtenances independently of connected piping.

5. Support no pipe from pipe above it or from metal stairs, ladders, or walkways unless it is so indicated on the Contract Drawings or specifically directed by the Engineer.

6. Supports shall be provided at changes in direction and elsewhere as shown on the Contract Drawings or specified herein.

7. Do not use adhesive anchors for attachment of supports to ceilings or walls.

8. Do not install pipe hangers or supports in equipment access areas or bridge crane runs.

9. Install hangers to provide a minimum of 1/2 inch space between finished covering and adjacent work.

10. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing and to reduce movement during startup and shutdown.

11. Install lateral supports for lateral loads at changes in direction.

12. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.

13. Repair mounting surfaces to original condition after attachments are completed.

B. Standard Pipe Supports:

1. Horizontal suspended piping:

a. Single pipes: Clevis hangers or adjustable swivel split ring.

b. Grouped pipes: Trapeze hanger system.

2. Horizontal piping supported from walls:

a. Single pipes: Wall brackets or attached to wall or to wall-mounted framing with anchors.

b. Stacked piping: Wall-mounted framing system and “J” hangers acceptable for pipe 3 inches and smaller.

c. Pipe hanger that resists axial movement of pipe through support is not acceptable. Use pipe rollers supported from wall bracket.

3. Horizontal piping supported from floors:

a. Saddle Supports:

1) Pedestal type, elbow and flange.

2) Provide minimum 1-1/2 inches of grout below baseplate.

b. Floor Mounted Channel Supports:

1) Use for pipe smaller than three inches running along floors and in trenches at pipe elevations lower than can be accommodated using pedestal pipe supports.

2) Attach channel framing to floors with baseplate on minimum 1-1/2 inches of non-shrink grout and with anchor bolts.

3) Attach pipe to channel with clips or pipe clamps

c. Concrete Cradles:

1) Use for pipe three inches and larger running along floors and in trenches at pipe elevations lower than can be accommodated using stanchion type.

4. Insulated piping:

a. Pipe hanger and support shall be on outside of insulation. Do not enclose within insulation.

b. Provide pre-cut 120 degree sections of rigid insulation (minimum length same as shield), shields and oversized hangers or insulated saddle system.

c. Wall-mounted pipe clips are not acceptable for insulated piping.

5. Vertical pipe:

   a. Support with wall bracket and elbow support, or riser clamp on floor penetration.

C. Standard Attachments

1. Existing concrete ceilings: Channel type support with minimum of two anchor points, concrete attachment plates or concrete anchors as limited below:

   a. Single point attachment to ceiling is allowed only for ¾ inch rod and smaller (8 inches and smaller pipe).

   b. Where there are vibration or bending considerations, do not connect a single point support hanger rod directly to a drilled concrete anchor (single point attachment) regardless of size.

2. Steel beams: I-beam clamps or welded attachments.

3. Concrete walls: Concrete inserts or brackets or clip angles with concrete anchors.

4. Concrete beams: Concrete inserts, or if inserts are not used, attach to vertical surface similar to requirements for concrete walls. Do not drill into beam bottom.

D. Intermediate and Pipe Alignment Guides

1. Provide pipe alignment guides, or pipe supports that provide same function, at expansion joints and loops.

2. Guide pipe on each side of expansion joint or loop at 4 pipe diameters and 14 pipe diameters from each joint or loop.

3. Install intermediate guides on metal framing support systems not carrying pipe anchor or alignment guide.

E. Accessories

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

2. Welding Insulation Saddle: Install on insulated steel pipe with oversize rollers and supports.

3. Dielectric barrier

a. Provide between painted or galvanized carbon steel members and copper or stainless steel pipe or between stainless steel supports and non-stainless ferrous metal piping.

b. Install rubber wrap between submerged pipe and oversized clamps.

END OF SECTION

Part 1 General

1.1 Section Includes

A. Wall Pipes

B. Floor Pipes

C. Pipe Sleeves

1.2 Related Sections

A. Section 40 23 00 – Water and Wastewater Process Piping

1.3 Submittals

A. Submit under provisions of Section 01 33 00.

B. Product Data: Provide data on materials, operational components, and accessories. Submit manufacturer's descriptive and technical literature for each component, including design recommendations; pressure and temperature ratings; dimensions; and chemical resistance to each chemical and chemical mixture in the [gas][and] [liquid] stream.

C. Operations and Maintenance Data: Submit under provisions of Section 01 78 23. Provide manuals for all operational devices.

Part 2 Products

2.1 Materials and Equipment

A. Piping specialties, appurtenances, and equipment supplied as part of this contract shall be of equal material and ratings as the connecting pipe, new and unused except for testing equipment.

B. Components that serve the same function and are the same size shall be identical products of the same manufacturer.

C. Pipe fittings shall be compatible with the applicable pipe materials.

D. Standard Products

1. Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacturing of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.2 Wall Pipes and Floor Pipes

A. Wall pipes and floor pipes shall be manufactured of ductile iron, grade 60-42-10, (minimum tensile strength: 60,000 psi; minimum yield strength: 42,000 psi; minimum elongation: 10%) in accordance with AWWA C151.

B. Ends shall be as shown on the drawings. Where required, flanges and MJ bells can be tapped for studs.

C. Wall pipe shall be fabricated of Special Class 53 thickness ductile iron pipe, unless otherwise noted.

D. Wall pipe shall be furnished with one fabricated thrust/water stop collar design with 360° fillet welds on both sides of the collar.

E. Unless otherwise noted, all cast-on flanges shall comply with AWWA C110 or C153, and all threaded-on flanges shall comply with AWWA C115.

F. All mechanical joints shall comply with AWWA C111. Threaded-on or otherwise fabricated MJ bells shall be per applicable portions of AWWA C115 and C153.

G. All wall pipes and floor pipes shall be provided with manufacturer's standard asphaltic coating.

2.3 Wall Sleeves

A. Galvanized Steel Sleeves

1. Provide galvanized steel sleeves for all pipes passing through concrete or masonry structures, or as shown on the Drawings. The sleeves shall be provided free of welding slag. Steel sleeve sizes though 10" shall be Schedule 40 Steel Pipe or standard wall thickness. Steel sleeve sizes 12" and larger shall have a 0.375" or standard wall thickness. Sleeves through wall shall be cast in place and the pipe shall be installed centered in sleeve. Provide minimum 2" x ¼" thick collar/water-stop of the same type of steel as the sleeve. The collar shall be welded all around on both sides to the sleeve at the point on the sleeve that positions it at the mid-point of the structural wall when the sleeve is in place. The galvanized steel sleeve with water-stop shall be galvanized inside and outside.

2. Sleeves shall be Garlock Pipeline Technologies WSG, or equal.

B. Stainless Steel Sleeves

1. Provide stainless steel sleeves for all pipes passing through concrete or masonry structures, or as shown on the Drawings. The sleeves shall be provided free of welding slag. Stainless steel sleeve shall be fabricated of [304][316] stainless steel. Stainless steel sleeve sizes though 10" shall be Schedule 40S pipe or standard wall thickness. Stainless steel sleeve sizes 12" and larger shall have a 0.375" or standard wall thickness. Sleeves through wall shall be cast in place and the pipe shall be installed centered in sleeve. Provide minimum 2" x ¼" thick collar/water-stop of the same type of steel as the sleeve. The collar shall be

welded all around on both sides to the sleeve at the point on the sleeve that positions it at the mid-point of the structural wall when the sleeve is in place.

C. Wall Penetrations

1. Above Grade Wall Penetrations: Piping which passes through fire-rated or smoke-rated walls, floors, or ceilings shall be provided with insulated and encased pipe sleeves. Penetrations through an existing fire or fire barrier wall shall be sealed with a fire stop system that has an "F" rating not less than the required fire resistance rating of the penetrated wall. The fire stopping sealant for metal piping systems shall be a water based, vibration resistant, polysiloxane (also known as silicone) based, nonslumping, premixed sealant with intumescent properties, that is rated for 3 hours pursuant to ASTM E814 and UL requirements. The fire stopping sealant for plastic and insulated piping systems shall be a polysiloxane (also known as silicone) based, nonslumping, premixed sealant with intumescent properties, that is vibration and moisture resistant, and is rated for 3 hours pursuant to ASTM E814 and UL requirements with metal collars. Vented plastic pipe penetrations shall be fitted with galvanized steel collars that have intumescent inlays.

D. Hydrostatic Seals

1. General Service: Modular seals shall be Model “C” LINK-SEAL® Modular Seal, or equal. Bolts and nuts shall be steel with 2-part Zinc Dichromate & proprietary corrosion inhibiting coating. Seal elements shall be made from Black EPDM materials, with reinforced Nylon Polymer Pressure plates.

2. Corrosive Duty/Wastewater: Modular seals shall be Model “S316” LINK-SEAL® Modular Seal, or equal. Bolts and nuts shall be 316 stainless steel. Seal elements shall be made from Black EPDM materials, with reinforced Nylon Polymer Pressure plates. Each shipment shall be packaged with a defining “NSF 61” label and batch number for traceability.

E. Galvanizing: Galvanizing shall be hot-dip applied and meet the requirements of ASTM A153/A153M. Stainless steel components may be substituted where galvanizing is specified.

Part 3 Execution

3.1 Examination

A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

3.2 Preparation

A. Protection: Pipe and equipment openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.

B. System Preparation

1. Provide accessibility to piping specialties for control and maintenance.

END OF SECTION

Item	Description
General	A. Pipe fittings shall be compatible with the applicable pipe materials. B. Identification and Tagging: Each piece of pipe shall bear the ASTM designation and all other markings required for that designation. C. All materials in contact with potable water shall be certified to NSF Standard 61 and Standard 372. D. Pipe supplier shall submit certification that source manufacturing facility has been producing ductile iron pipe of the specified diameters, dimensions, and standards for a period of not less than 10 years. E. Testing of pipe required by AWWA A21.51 shall be conducted in testing and laboratory facilities located in the USA and operating under USA laws and regulations. F. Pipe shall be handled during manufacture and shipped without nesting (i.e., insertion of one pipe inside another)
Pipe	A. Buried 1. Mechanical Joint: AWWA C111/A21.11 and AWWA C151/A21.51, minimum pressure class 250. Follower glands shall be ductile iron. 2. Restrained Joint: AWWA C111/A21.11 and AWWA C151/A21.51, minimum pressure class 250. Follower glands shall be ductile iron. B. Exposed/Aboveground 1. Grooved: AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure. 2. Flanged: AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure.
Lining	A. Cement Mortar: Standard cement lining conforming to AWWA C104/A21.4
Coatings	A. Underground ductile iron piping shall be coated with the manufacturer's standard asphaltic coating, approximately 1 mil thick, applied to the outside of pipe and fittings. B. Above-ground or exposed ductile iron piping shall be factory primed with a paint system compatible with the paint systems specified in Section 09 90 15.
Fittings	A. Lined and coated same as pipe. B. Mechanical: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53 ductile iron, 250 psig minimum working pressure. Follower glands shall be ductile iron. C. Restrained Joint: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53, ductile iron, 250 psi minimum working pressure. Restraint shall be

	achieved with mechanical joints, restrained by anchor gland followers, ductile iron anchor type, wedge action, with break-off tightening bolts. Restrained joints relying on metal teeth molded into the gasket will be accepted as an alternate. D. Grooved End: AWWA C606 and AWWA C110/A21.10, ductile iron, 250 psi minimum working pressure, Victaulic or equal. E. Flanged: AWWA C110/A21.10 ductile iron, faced and drilled, Class 250 flat face. Gray cast iron will not be allowed.
Joints	A. Mechanical: 250 psig minimum working pressure. B. Restrained Joint: 250 psi minimum working pressure. C. Grooved End: Rigid type radius cut conforming to AWWA C606. 250 psi minimum working pressure, Victaulic or equal. D. Flanged: [1]Class 125 flat face. Ductile iron, threaded conforming to AWWA C115/A21.15. Gray cast iron will not be allowed. E. Branch Connections: Connections 3 inches and smaller shall be made with service saddles as specified in Section 40 05 06.
Couplings	A. Grooved End: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536, Victaulic. B. Grooved End Adapter Flanges: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536, Victaulic.
Bolting	A. Mechanical, Restrained, and Grooved End Joints: Manufacturer's standard. B. Flanged: Bolts and accessories shall be carbon steel conforming to the requirements of ASTM A307, Grade B.
Gaskets	A. General: Gaskets in contact with potable water shall be NSF 61 certified. B. Mechanical and Restrained Joints - Water and Sewage Service: Rubber conforming to AWWA C111/A21.11. C. Grooved End Joints: EPDM conforming to ASTM D2000 and AWWA C606. D. Flanged – Liquid Service: Gaskets shall be 1/8 inch thick, vulcanized synthetic rubber, reclaimed rubber is not acceptable.
Joint Lubricant	Manufacturer's Standard

END OF SECTION

Item	Size	Description
General		A. Pipe fittings shall be compatible with the applicable pipe materials. B. Identification and Tagging: Each piece of pipe shall bear the ASTM designation and all other markings required for that designation. C. All materials in contact with potable water shall be certified to NSF Standard 61 and Standard 372. D. Pipe supplier shall submit certification that source manufacturing facility has been producing steel pipe of the specified diameters, dimensions, and standards for a period of not less than 10 years. E. Pipe shall be handled during manufacture and shipped without nesting (i.e., insertion of one pipe inside another)
Pipe	2” and smaller	ASTM A312/A312M, seamless, Grade TP304L, pickled and passivated, Schedule 40S with dimensions conforming to ASME B36.19.
	2-1/2” and larger	Manufactured from ASTM-A240 annealed and pickled sheets and plates in accordance with ASTM A778, Grade TP304L, with dimensions conforming to ASME B36.19.
	2-1/2” to 16”	Schedule 20
	18” to 24”	Schedule 30
	26” to 36”	Schedule 20
Fittings	1-1/2” and smaller	Threaded Fittings: Forged, 1000 psi CWP, austenitic stainless steel, ASTM A182/A182M Grade TP304L, TP316, TP316L, conforming to ASME B16.11, and threaded in accordance with ASME B1.20.1.
	2” and 2-1/2”	Welding Fittings: Butt-weld type, ASTM A403/A403M, material matching piping; annealed, pickled and passivated; fitting wall thickness to match adjoining pipe; long-radius elbows unless shown otherwise. Grooved: Grooved fittings shall use Victaulic L07 Rigid couplings and matching groove profile, or approved equal.
	3” and larger	Welding Fittings: Welding fittings shall be butt-weld type, material matching piping, ASTM A774/A774M, pickled and passivated; fitting wall thickness to match adjoining pipe; long-radius elbows unless shown otherwise.

		Grooved: For pipe diameters 3” through 12”, grooved fittings shall use Victaulic Style L07 Rigid Coupling and matching groove profile, or approved equal. For pipe diameters 14” and larger, grooved fittings shall use AGS Rigid Coupling Style W07 couplings and matching groove profile, or approved equal.
Joints	2” and smaller	Threaded or flanged at valves and equipment, as required or shown.
	2-1/2” and larger	Butt-welded or flanged at valves and equipment.
Branch Connections	1-1/2” and smaller	Threaded straight or reducing tees in conformance with fittings specified above. For welded or grooved pipe, use threadolet.
	2” and larger	Butt-welding tee in conformance with fittings specified above.
Flanges	All	Forged stainless steel, ASTM A182/A182M, Grade F304L or F316L, ASME B16.5, slip-on or welding neck, faced and drilled to ASME B16.5 [1]Class 150 with a 1/16 inch raised face. Weld-on slip-on flanges inside and out. Cast carbon steel: ASTM A216/A216M, Grade WCA, drilled, ASME B16.5 [1]Class 150 Van Stone type with stainless steel stub ends, ASTM A240 Type 304L or 316L, conforming to MSS SP43, wall thickness same as pipe. Blind flanges, exposed to atmosphere and not immersed in liquid or buried, may be stainless steel, Class 250 ductile iron, or Class 300 carbon steel with gaskets as specified herein.
Unions	2” and smaller	Threaded forged: ASTM A182/A182M, Grade F316, 2000- or 3000-pound WOG, integral ground seats, AAR design meeting the requirements of ASME B16.11, bore to match pipe.
Bolting	All	Forged flanges and flanged joints in sumps, wet wells, submerged and wetted installations: ASTM A320, Grade B8M, Class 1 hex head bolts, ASTM A194/A194M Grade 8H hex nuts, and ASTM F436 washers at nuts and bolt heads. Achieve 40 to 60 percent of bolt minimum yield stress. Use anti-seize coatings in assembly of nuts and bolts.

		Van Stone Flanges and anywhere mating flange on equipment is cast iron and gasket is flat ring: Carbon steel A307 Grade B hex head bolts, ASTM A563 Grade A hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 to 60 percent of bolt minimum yield stress.
Gaskets	All flanges	General: Gaskets in contact with potable water shall be NSF 61 certified. 1/8 inch thick EPDM, hardness No.60 (Shore A), rated 250 degrees continuous and conforming to ASME B16.21, and ASTM D1330, Steam Grade.
Thread Lubricant		Nickel-pigmented Polytetrafluoroethylene (PTFE) pipe-thread tape designed for stainless steel pipe. Fuel service: Yellow PTFE tape designed for fuel gas service.

END OF SECTION

Item	Size	Description
General		A. Pipe fittings shall be compatible with the applicable pipe materials. B. Identification and Tagging: Each piece of pipe shall bear the ASTM designation and all other markings required for that designation. C. All materials in contact with potable water shall be certified to NSF Standard 61 and Standard 372. D. PVC Pipe shall be colored, with the entire pipe being cast in a uniform color. The pipe colors shall be as follows: 1. Potable Water – Blue 2. Sewer – Green 3. Effluent Reuse – Purple 4. Other Liquids - White E. Pipe shall be handled during manufacture and shipped without nesting (i.e., insertion of one pipe inside another). F. Pipe shall be manufactured with titanium dioxide for UV protection.
Pipe	3" and smaller	ASTM D1784, minimum cell classification 12454. Pipe shall be Schedule 80 conforming to D1785. Threaded nipples: Schedule 80 PVC.
Fittings	3" and smaller	Schedule to match pipe above. ASTM D2466 and ASTM D2467 for socket weld type and Schedule 80 ASTM D2464 for threaded type. Fittings shall be manufactured with titanium dioxide.
Joints	3" and smaller	Solvent socket weld except where connection to threaded valves and equipment may require future disassembly.
Flanges	All	One-piece, molded hub type PVC flat face flange in accordance with fittings above. ASME B16.1, 125 # drilling.
Gaskets	All flanges	General: Gaskets in contact with potable water shall be NSF 61 certified. Flat face mating flange: Full faced, 1/8 inch thick Ethylene Polypropylene (EPM) rubber. Raised face mating flange: Flat ring, 1/8 inch thick Ethylene Polypropylene (EPM) rubber, with

		filler gasket between OD of raised face and flange OD to protect flange from bolting moment.
Solvent Cement	All	Socket connections shall be joined with PVC solvent cement conforming to ASTM D2564. Manufacture and viscosity shall be as recommended by the pipe and fitting manufacturer to assure compatibility. Joints shall be prepared with primers conforming to ASTM F656 prior to cementing and assembly.
Thread Lubricant		Polytetrafluoroethylene (PTFE) pipe-thread tape.

END OF SECTION

Part 1 General

1.1 Related Sections

A. Section 40 05 57 - Actuators for Process Valves and Gates.

B. Section 40 05 62 - Plug Valves.

1.2 System Description

A. This specification covers the requirements for above and below grade liquid process valves and accessories located both inside and outside of treatment plants.

B. Performance Requirements

1. Flanges, valves, fittings and appurtenances shall have a pressure rating no less than that required for the system in which they are installed.

1.3 Maintenance

A. Service: Services for automatic valve systems shall be provided by a manufacturer's representative who is experienced in the installation, adjustment and operation of the equipment specified. The representative shall inspect the installation and supervise the adjustment and testing of the equipment.

B. Extra Materials

1. Submit the manufacturer's installation recommendations or instructions for each material or procedure to be utilized, including materials preparation. Concurrent with delivery and installation, spare parts for each different item of material and equipment specified that is recommended by the manufacturer to be replaced any time up to 1 year of service shall be furnished. For each type and size of valve, the following extra materials shall be provided: lubricator, lubricant (with appropriate temperature rating), lubricator/isolating valve. Extra materials shall include 2 of the following spare parts for each type and size of valve: gaskets; O-ring seals; all elastomer parts; and stem packing..

Part 2 Products

2.1 Materials and Equipment

A. Provide valves and appurtenances as specified and as shown on the drawings, and suitable for the service intended. Valves, appurtenances, and equipment supplied as part of this contract shall be of equal material and ratings as the connecting pipe, new and unused except for testing equipment.

B. Components that serve the same function and are the same size shall be identical products of the same manufacturer.

C. Identification and Tagging:

1. Valves shall be marked in accordance with MSS SP-25 and shall bear an identification tag securely attached using stainless steel wire. Identification tags shall be 1.5 inch minimum diameter, made of engraved laminated plastic The service, valve identification number shown on the Valve Schedule in the contract drawings, the manufacturer's name, and the valve model number shall be displayed.

2. Buried valves shall be installed with a valve identification disc attached to the surface of the concrete placed around the valve box. A valve extension stem and floor box shall also have a valve identification disc installed on the concrete floor adjacent to the floor box. Valve identification discs shall be 2 inch diameter, 1/8 inch thick bronze discs with etched lettering and be attached to the concrete in the manner shown on the drawings. Identification shall be as listed below:

   a. Line content or function

   b. Valve number as listed in the Valve Schedule

   c. Arrow mark indicating the direction of rotation to open, with the word OPEN beside it.

2.2 Valves

A. General Requirements for Valves

1. Valves shall include operator, actuator, handwheel, chain wheel, extension stem, floor stand, worm and gear operator, operating nut, chain, wrench, and all other accessories required for a complete operation from the intended operating level.

2. The valves shall be suitable for the intended service. Renewable parts are not to be of a lower quality than those specified.

3. Valves shall be the same size as adjoining pipe, unless otherwise noted.

4. Valve ends shall be compatible with adjacent piping system.

5. An operator shall be sized to operate the associated valve for the full range of pressures and velocities.

6. Valves will open by turning counterclockwise.

7. Operators, actuators, and accessories shall be factory mounted.

8. All exterior nuts, bolts, fasteners, etc. shall be stainless steel or other non-corrosive material.

B. Valve Schedule

1. Submit a list of valve materials, pressure ratings, valve operator materials, air supply pressure, electrical service, location, source of supply, and reference

tools necessary for each valve type and appurtenances furnished for adjustment, operation, maintenance, and disassembly.

C. Factory Finishing: Valves and actuators shall have an epoxy coating in accordance with AWWA C550 unless otherwise specified. The epoxy shall be either a two-part liquid material or a heat-activated (fusion) material except that only a heat-activated material shall apply if a valve coating is specified as "fusion" or "fusion bonded" epoxy. The epoxy coating shall have a minimum 7.0 mils dry film thickness except where it is limited by valve operating tolerances. Exposed valves shall be finished with a Hi-Solids Polyurethane coating equal to Tnemec Series 1073 or Sherwin Williams B65-300, minimum 2.5-3.0 Mils, with color to be selected by the Owner.

2.3 Materials

A. Bronze and brass valve components and accessories that have surfaces in contact with potable water to be alloys meeting Federal lead-free requirements. Stainless steel alloy 18-8 may be substituted for bronze.

Part 3 Execution

3.1 Examination

A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

3.2 Valve Installation

A. Flanged valve bolt holes shall be installed so as to straddle the vertical centerline of pipe. Flanged faces shall be cleaned prior to inserting the gasket and bolts, and then the nuts shall be tightened progressively and uniformly. Threaded ends shall have the threads cleaned by wire brushing or swabbing prior to installation.

B. Valve Orientation

1. The operating stem of a manual valve shall be installed in a vertical position when the valve is installed in horizontal runs of pipe having centerline elevations 4.5 feet or less above finished floor, unless otherwise shown on contract drawings. The operating stem of a manual valve shall be installed in a horizontal position in horizontal runs of pipe having centerline elevations between 4.5 feet and 6.75 feet above finish floor, unless otherwise shown on contract drawings. Automatic valves shall be installed in accordance with the manufacturer's instructions and approved drawings.

2. Plug Valves: If a plug valve seat position is not shown in the contract drawings, locate the seat position as follows: for horizontal flow, the flow shall produce an "unseating" pressure, and the plug shall open into the top half of valve; and for vertical flow, the seat shall be installed in the highest portion of the valve.

3. Torque Tube: Where shown an extension stem torque tube shall be furnished, properly sized for the maximum torque capacity of the valve.

3.3 Valve Testing

A. Submit copies of all field test reports within 24hours of the completion of the test.

B. Valves may either be tested while testing pipelines, or as a separate step.

C. Demonstrate that valves open and close smoothly with operating pressure on one side and atmospheric pressure on the other, and in both directions for two-way valve applications.

D. Count and record the number of turns required to open and close each valve, and account for any discrepancies with manufacturer's data.

E. Air and vacuum relief valves shall be examined as the associated pipe is being filled to verify venting and seating is fully functional.

F. Set, verify, and record set pressures for all relief and regulating valves. Self-contained automatic valves shall be tested at both maximum and minimum operating ranges, and reset upon completion of test to the design value. Automatic valves that are not self-contained shall be tested in conjunction with control system testing.

END OF SECTION

Part 1 General

1.1 Section Includes

A. This specification covers the requirements for actuators, both manual and electric, for above and below grade liquid process valves inside treatment plants.

B. Valve manufacturer shall be responsible for mounting actuators on valves supplied under other sections and shall be responsible for coordinating the mounting of the actuators.

1.2 Related Sections

A. Section 09 90 15 - Paints

B. Section 40 05 62 - Plug Valves

1.3 Submittals

A. Submit in accordance with Section 01 33 00.

B. Shop Drawings:

1. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.

2. Power and control wiring diagrams, including terminals and numbers.

3. For each power actuator provided, Manufacturer's standard data sheet, with application specific features and options clearly identified.

4. Sizing calculations for open-close valves.

C. Manufacturer's Certificate: Submit Manufacturer's Certificate of Compliance for:

1. Electric actuators: full compliance with AWWA C542.

D. Operations and Maintenance Data: As specified in Section 01 78 23.

1. Submit 6 copies each of operation and maintenance manuals in indexed booklet form. Detail in the Operation Manuals the step-by-step procedures required for specialized startup, operation and shutdown of piping systems, and include the manufacturer's name, model number, parts list and brief description of piping equipment such as valves and other appurtenances and their basic operating features.

2. List in the Maintenance Manuals routine maintenance procedures and troubleshooting guides for the equipment.

Part 2 Products

2.1 Materials and Equipment

A. Provide valve actuators as specified and as shown on the drawings, and suitable for the service intended.

B. Components that serve the same function and are the same size shall be identical products of the same manufacturer.

C. All iron and steel components shall be manufactured in the United States in conformance with funding agency requirements.

D. Standard Products

1. Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacturing of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.2 Actuators

A. Manual Operators:

1. The force in a manual operator shall not exceed 40 pounds under any operating condition, including initial breakaway. The operator shall be equipped with gear reduction when the force exceeds 40 pounds. The manual operator shall be a self-locking type or shall be equipped with a self-locking device. A position indicator shall be supplied on quarter-turn valves. Worm and gear operators shall be a one-piece design with worm-gears of gear bronze material. Worm shall be hardened alloy steel with the thread ground and polished. Traveling nut type operators shall have threaded steel reach rods with an internally threaded bronze or ductile iron nut.

2. Exposed Operators: Exposed operators shall have galvanized handwheels. Lever operators are allowed on quarter-turn valves 8 inches and smaller. Cranks shall be supplied on gear type operators. If located higher than 6 feet above the operator floor, chain wheel operator with tiebacks, extension stem, floor stands, and other accessories shall be provided to permit operation from normal operation level. Valve handles shall be capable of padlocking, and wheels shall be lockable with a chain and padlock.

3. Buried valves shall have extended bonnets with an enclosed drive shaft that allows the geared operators to be mounted above grade. The moving parts of the valve and operator shall be enclosed in a housing to prevent contact with the soil. The extended bonnet shall be standard weight steel tube with epoxy coating. The enclosed drive shaft extension shall be 304 SSTL. The installation contractor shall brace the extended bonnet outer tube at a maximum spacing of 10 feet.

4. Operators for quarter-turn valves shall be designed to operate the valve at the maximum operating pressure listed in the valve schedule, and to withstand a

450 foot-pound input torque at the fully open and fully closed positions, whichever is greater.

B. Electric Motor Operators

1. Electric operators shall be provided complete with actuators, speed controls and accessories. Actuators shall comply with AWWA C542. The actuators shall operate on 460V, 3phase, 60 Hz. Open/close valves shall have a 30 percent duty cycle. Actuators shall be equipped with an AC thermal overload protector with automatic rest, reversing (bi-directional) operation for use with quarter-turn valves, or rotating equipment to full rotation. Gearing shall be a two-stage planetary, permanently lubricated self-locking gear train with self-lubricating bearings, connections via male output staff. Two travel stop limit switches with cams, internal, independent, adjustable, and actuated by cams shall be mounted on the drive shaft. A side mounted hand turn wheel shall be provided for a manual override. The actuators shall have a NEMA 250 Type 4 enclosure with a corrosion resistant, baked epoxy finish as standard. The actuator shall operate in a temperature range of minus 40 to plus 150 degrees F. Actuators shall fail in last position unless otherwise indicated.

2. Limit Switches. Limit switches shall be single-pole, double-throw (SPDT) type, rated 10 amps at 120 volts ac, housed in a NEMA 250 Type 4 enclosure, and adjustable for open and closed valve positions.

3. Manufacturer / Product:

a. Limitorque MX Series

Part 3 Execution

3.1 Examination

A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

3.2 Preparation

A. Protection: Openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.

END OF SECTION

Part 1 General

1.1 Work Included

A. Furnish and install slide/stop gates in the sizes and locations shown, complete and operable, including electric operators, bracing, frame, mountings, etc.

1.2 Related Sections

A. Section 09 90 15 - Paints.

B. Section 40 05 57 – Actuators for Process Valves

1.3 Contractor Submittals

A. Shop Drawings:

1. Complete shop drawings of all gates, frames, slides, and operators.

2. Manufacturer’s Catalog Information, Descriptive Literature, Specifications, and Identification of Materials of Construction.

3. Design load calculations for deflection at the maximum expected head, and calculations for the lifting force required to lift the gate with 40 pounds effort on the handwheel or crank.

B. Certifications:

1. Manufacturer’s Certificate of Compliance.

2. Manufacturer’s Certificate of Proper Installation.

3. Electric actuators: full compliance with AWWA C542.

C. O&M Information Shall Be Submitted in Accordance with Section 01 78 23.

D. Operations and Maintenance Data

1. Manufacturer’s printed installation instructions.

2. List of recommended spare parts for a period of 1 year.

1.4 Quality Assurance

A. The leakage allowance for slide gates shall not exceed 0.1 gpm/ft of seating perimeter under 20 ft of seating head, and 0.2 gpm/ft under 20 ft of unseating head, to meet ANSI/AWWA C-501.

Part 2 Products

2.1 General Requirements

A. All gates shall be new and of current manufacture, and adequately braced to prevent warpage and bending under the intended use.

B. All gates shall be rising stem type.

C. Where designated, gates shall be furnished with electric operators provided by the gate manufacturer in compliance with Spec 40 05 57. All operators of a given type shall be furnished by the same manufacturer.

D. All gates shall be furnished with a handwheel; crank-operated or electrically operated floor stand, having a 2:1 gear ratio; or 2-inch square operating nut, as listed in the gate schedule, and shall conform to ANSI/AWWA C542, except as otherwise specified herein.

E. Operating Mechanism: operators shall be weatherproof, equipped with stem covers, and shall be mounted on cast-iron or fabricated steel pedestals. The pedestal shall have an ample base or bracket area to evenly distribute the load to the supporting structure. The center line of the manual operator shall be approximately 3-feet above the base of the pedestal. The unit shall be designed so that a maximum of 40 pounds effort on the crank will operate the gate. Clockwise movement of the handwheel shall close the gate. The operating crank shall be easily removable to facilitate the use of a portable power operator.

F. Stems: Stems shall be of type 316 stainless steel, with 1” minimum diameter, and shall be provided with adjustable cast iron, bushed stem guides, mounted on cast iron brackets, to ensure that the l/r ratio of the stem does not exceed 200.

G. Stem Covers: transparent plastic, with vented pipe stem cover and cap. Provide with open/closed designators.

H. Components that serve the same function and are the same size shall be identical products of the same manufacturer.

I. Standard Products

1. Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacturing of the products and that essentially duplicate items that have been in satisfactory use for at least 3 years prior to bid opening.

2.2 Materials

A. Aluminum Plate and Shapes: ASTM B209 and ASTM B308, Alloy 6061-T6.

B. Stainless Steel:

1. Plate, Sheet, and Strip: ASTM A240, Type 316L

2. Bars and Shapes: ASTM A276, Type 316L

2.3 Aluminum Slide Gates

A. Construction: Aluminum slide gates shall be self-contained, or as shown, crank or handwheel-operated, with type 316 stainless steel operating stem. Gates shall conform to AWWA C562. The gates shall have stiffeners, extruded aluminum frames with bearing bars of ultra-high molecular weight polymer, resilient p-seals, and fully lubricated stems and operators.

B. Manufacturers:

1. Whipps

2. Golden Harvest

3. H. Fontaine, Ltd.

2.4 Stainless Steel Slide Gates

A. Construction: stainless steel slide gates shall be self-contained, or as shown, with operator as shown and type 316 stainless steel operating stem. Gates shall conform to AWWA C561. The gates shall have stiffeners and shall be designed so that the plate shall not deflect more than 1/360 when under normal operating differential head. Frames shall be extruded stainless steel with bearing bars of ultra-high molecular weight polymer, resilient p-seals, and fully lubricated stems and operators.

B. Cleaning and Finishing Stainless Steel Welded Fabrication:

1. Cleaning of weld joints and weld joint areas both before and after welding, shall conform to ASTM A380. Use only stainless-steel brushes or stainless-steel wool.

2. Finishing: all weld areas following fabrication shall be pickled to remove all mill scale, weld inclusions, and color, and passivated in conformance to ASTM A380.

3. Contractor shall submit the cleaning and passivation procedure in compliance with the above requirements for engineer’s review and approval.

C. Manufacturers:

1. Whipps

2. Golden Harvest

3. Fontaine Aquanox,

Part 3 Execution

3.1 Installation

A. Slide/stop gates shall be installed in strict accordance with the manufacturer's printed recommendations and the requirements herein. Operators shall be located to avoid interference with handrails and structural members.

B. All damage to surface coatings incurred during shipment and/or installation shall be repaired to the satisfaction of the engineer prior to installation.

C. Level gate vertically and horizontally, with bolting and the use of shims between the frame and the concrete surface. Grout space between gate frame and concrete surface with non-staining non shrink grout. Remove shims after grout sets.

D. Lubricate stems, manual gear boxes, and electrical operators in accordance with manufacturer’s instructions before operating.

Slide Gate Schedule									
Tag No.	Style	Concrete Opening Height	Concrete Opening Width	Material	Design Operating Head:			Operator Type	Notes
					Seating	Unseating			
SG-9110	D	4’-0”	4’-0”	Stainless Steel or Aluminum	12	12		Electric Open/Close	Wet Well Isolation
SG-9120	D	4’-0”	4’-0”	Stainless Steel or Aluminum	12	12		Electric Open/Close	Wet Well Isolation

Legend:

Style A: upward acting type for mounting on face of channels with concrete embedded invert.

Style B: upward acting type for mounting in channels with concrete embedded frame and invert.

Style C: downward acting weir gate with invert seal for wall surface mounting frame and invert on the concrete structures.

Style D: upward acting type with full-aperture sealing with frame and invert for mounting on face of wall.

Notes:

Head calculated to centerline of gates

END OF SECTION

Part 1 General

1.1 Section Includes

A. Eccentric Plug Valves for Liquid Service.

1.2 Related Sections

A. Section 09 90 15 - Paints

B. Section 40 05 51 - Common Requirements for Process Valves.

C. Section 40 05 57 - Actuators for Process Valves and Gates.

Part 2 Products

2.1 Eccentric Plug Valves for Liquid Service

A. Eccentric Plug Valve, 14” to 20”

1. Nonlubricated type eccentric valves rated for 100 psig service at 140 degrees F. Valves shall have drip-tight shutoff with pressure from either direction, and cast iron bodies. Exposed service valves shall have flanged ends in accordance with ASME B16.1 Buried service valves shall have mechanical joint ends, unless otherwise noted.

2. Plug shall be all metal, matching body with round or rectangular port, fully ported, and coated with Buna-N, welded nickel seats, self-lubricating stainless steel stem bearings, and stem seal multiple V-rings or U-cups with O-rings of nitrile rubber, with grit seals on both upper and lower bearings. Totally enclosed, geared, manual operator with handwheel or 2-inch nut. Size operator for 1.5 times the maximum shutoff pressure differential for direct and reverse pressure, whichever is higher.

3. Manufacturers and Products:

   a. DeZurik

   b. Valmatic

   c. Pratt

   d. Golden Anderson

B. Eccentric Plug Valve, 24” to 48”

1. Non-lubricated type eccentric valves rated for 100 psig service. Valves shall have drip-tight shutoff with pressure from either direction, and cast iron bodies. Exposed service valves shall have flanged ends in accordance with ASME

B16.1. Buried service valves shall have mechanical joint ends, unless otherwise noted.

2. Plug shall be all metal, matching body with round or rectangular port, fully ported, and coated with Buna-N, welded nickel seats, self-lubricating stainless steel stem bearings, and stem seal multiple V-rings or U-cups with O-rings of nitrile rubber, with grit seals on both upper and lower bearings. Totally enclosed, geared, manual operator with handwheel or 2-inch nut. Size operator for 1.5 times the maximum shutoff pressure differential for direct and reverse pressure, whichever is higher.

3. Buried valves shall have extended bonnets with an enclosed drive shaft that allows the geared operators to be mounted above grade. The moving parts of the valve and operator shall be enclosed in a housing to prevent contact with the soil. The extended bonnet shall be standard weight steel pipe with epoxy coating. The enclosed drive shaft extension shall be 304 SSTL. The installation contractor shall brace the extended bonnet outer tube at a maximum spacing of 10 feet apart.

4. Manufacturers and Products:

   a. DeZurik

   b. Valmatic

   c. Pratt

   d. Golden Anderson

Part 3 Execution

3.1 Examination

A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

END OF SECTION

Part 1 General

1.1 Section Includes

A. Swing Check Valves

1.2 Related Sections

A. Section 09 90 15 - Paints

B. Section 40 05 51 - Common Requirements for Process Valves.

C. Section 40 05 57 - Actuators for Process Valves and Gates.

Part 2 Products

2.1 Swing Check Valves

A. Type V801 Swing Check Valves, 2 inch through 36 inch.

1. Swing Check Valves shall conform to AWWA C508, and have ASME B16.1 Class 125 flanged or grooved end connections. Valves shall have a ductile iron or cast iron body, stainless steel body seat, ductile iron disc arm, ductile iron disc with Buna-N rubber seal, and a stainless steel hinge shaft. Valves shall be rated for 250 psig service at 140 degrees F. Valves shall be fitted with an adjustable outside lever and weight.

2. Acceptable manufacturers and products:

   a. GA Industries Figure 220

Part 3 Execution

3.1 Examination

A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

3.2 Preparation

A. Protection: Openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.

END OF SECTION

Part 1 General

1.1 Section Includes

A. Air Release Valves for Wastewater Service

B. Air/Vacuum Valves for Wastewater Service

1.2 Related Sections

A. Section 09 90 15 - Paints

B. Section 40 05 51 - Common Requirements for Process Valves.

C. Section 40 05 57 - Actuators for Process Valves and Gates.

Part 2 Products

2.1 General

A. Air Release and Vacuum Breakers

1. Air release vents shall be located, and vented, such that a hazardous atmosphere will not be created upon operation.

2. Locations: Air release and vacuum breakers shall be located as indicated on the contract drawings.

2.2 Air/Vacuum Valves for Wastewater Service

A. This specification covers automatic valves installed on wastewater mains to vent accumulated air under system pressure, and to provide air exhaust during initial fill or to prevent a vacuum during draining or water column separation of the system. The air and vacuum valve shall comply with AWWA C512.

B. The air and vacuum valve shall be designed with the inlet and outlet of equal cross-sectional area where applicable. The valve shall be capable or automatically allowing large quantities of air to be exhausted during the filling cycle an also capable of automatically allowing air to re-enter the system to prevent a negative pressure at water column separation or during the draining cycle. The float shall be guided to minimize premature closure by air and to provide proper alignment for normal closure by floating on the water surface.

C. Cast Iron Sewage Air Vacuum Valves through 4”

1. Cast iron valve body and cover shall be in accordance with ASTM A48-35 or ASTM A126 class B. Inlet sizes through 2 inches shall be screwed (NPT), larger sizes shall be flanged.

2. Metallic internal seat trim float arm and pivot pin shall be stainless steel type 303, 304 or 316. Metallic floats shall be stainless steel ASTM A240. Other stainless steel metal internal parts shall be stainless steel ASTM A240 or ASTM A276.

3. Valves requiring internal seats or orifice buttons shall be Buna-N rubber compounded for water service. For valves requiring cover gaskets, the cover gasket shall be composition type, equal to Armstrong CS-231, Garlock 3000, or Lexide NK-511. If an O-Ring is used to seal the cover, it shall be on NSF 61 certified rubber. Cover bolts shall be alloy steel.

4. Valve body shall have a test pressure rating of 500 psi and working pressure rating of 150 psi.

5. The air release valve shall be designed to vent accumulated air automatically. The outlet orifice shall be properly sized to facilitate valve operation at pressures up to 150 psi. The air release valve shall be simple-lever or compound-lever depending upon volume requirements and the design of the valve.

6. Manufacturer/Model:

   a. DeZurik/Apco 401.

C. Stainless Steel Air Vacuum Valve

1. Valve shall be stainless steel and shall allow for uninterrupted discharge of air/gas during filling, continuous discharge of dis-entrained pressurized air/gas, unrestricted vacuum break, and pipeline surge protection in a single chamber. Valves shall be anti-surge and antishock air release and vacuum break valves.

   a. The large orifice shall allow air to escape during pipeline filling and allow air intake during pipeline draining.

   b. The small orifice shall release air accumulations after the pipeline is filled, under pressure and in operation.

   c. The valve shall be equipped with an integral surge alleviation mechanism that automatically dampens surge pressures due to rapid air discharge or the subsequent rejoining of separated water columns.

2. Construction and Design

   a. Valve shall utilize solid unbreakable HDPE floats with EPDM O-Ring seals. Floats must not deform, leak or experience damage of any kind at twice the design pressure, with floats providing continuous discharge of pressurized air release without levers, pins, springs that can break.

3. Manufacturer shall have IS0 9001, and third party testing of vacuum and air release flow coefficient to certify sizing and performance of all functions.

4. Valve shall have a 10 year in-service warranty for all internal components.

5. The valves furnished shall be standard products in regular production by the manufacturer and shall have been in satisfactory and successful operation for a period of at least five (5) years.

6. Materials of Construction:

    a. 304 stainless steel barrel, flanges, top cover and fasteners, tie rods, and fasteners.

    b. Floats: High Density Polyethylene

7. Manufacturer & Model

    a. Valmatic Model 301

Part 3 Execution

3.1 Examination

A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

3.2 Preparation

A. Protection: Openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.

3.3 Valve Testing

A. Submit copies of all field test reports within 24 hours of the completion of the test.

B. Air and vacuum relief valves shall be examined as the associated pipe is being filled to verify venting and seating is fully functional.

END OF SECTION

Part 1 General

1.1 Section Includes

A. This specification covers the requirements for above and below grade wastewater process piping located within the treatment plant.

1.2 Related Sections

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

B. Section 09 90 15 – Paints.

C. Section 40 05 06 - Couplings, Adapters, and Specials for Process Piping.

D. Section 40 05 07 - Pipe Hangers and Supports.

E. Section 40 05 09 – Wall Pipes, Floor Pipes, and Pipe Sleeves.

1.3 Definitions

A. Submerged or Wetted: The zone below:

1. Top face of channel walls and top slabs.
2. Top face of aeration basin and digester basin walls and walkways.
3. Top face of clarifier walkways.
4. Two feet above the maximum liquid surface.
5. Top of tank wall or under tank cover.

1.4 System Description

A. Design Requirements: Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:

1. Process Piping: ASME B31.3, normal fluid service unless otherwise specified.
2. Building Service Piping: ASME B31.9, as applicable.
3. Sanitary Building Drainage and Vent Systems: ICC International Plumbing Code and local plumbing code.
4. Buried Piping: Piping systems shall be suitable for design conditions, considering the piping both with and without internal pressure. Consideration

shall be given to all operating and service conditions both internal and external to the piping systems.

5. Above Grade Piping Systems: Piping systems shall be suitable for design conditions, considering the piping both with and without internal pressure, and installation factors such as insulation, support spans, and ambient temperatures. Consideration shall be given to all operating and service conditions both internal and external to the piping systems.

B. Performance Requirements: The pressure ratings and materials specified represent minimum acceptable standards for piping systems. The piping systems shall be suitable for the services specified and intended. Each piping system shall be coordinated to function as a unit. Flanges, valves, fittings and appurtenances shall have a pressure rating no less than that required for the system in which they are installed.

1.5 Submittals

A. The following shall be submitted in accordance with Section 01 33 00.

B. Shop Drawings:

1. Submit manufacturer's descriptive and technical literature for each piping system, including design recommendations; pressure and temperature ratings; dimensions, type, grade and strength of pipe and fittings; thermal characteristics (coefficient of expansion and thermal conductivity); and chemical resistance to each chemical and chemical mixture in the liquid stream.

2. Equipment shop drawings and support system detail drawings showing piping systems and appurtenances, such as mechanical joints, valves, local indicators and hangers, including a complete list of equipment and materials.

C. Certifications:

1. Provide manufacturer’s certification of compliance with AWWA C111 for all mechanical joint bolts with each shipment.

D. As-built drawings showing pipe anchors and guides, and layout of piping systems relative to other parts of the work including clearances for maintenance and operation. As-built piping and instrumentation diagrams (P&IDs) identifying and labeling equipment, instrumentation, valves, vents, drains, and all other inline devices; if the contract drawings contained P&IDs, the P&IDs found in the contract drawings shall be revised to reflect the constructed process system.

E. Special Tools: A list of any special tools necessary for each piping system and appurtenances furnished for adjustment, operation, maintenance and disassembly of the system.

1.6 Qualifications

A. Contractor: Submit a statement certifying that the Contractor has the specified experience. Contractor shall have successfully completed at least 3 projects of the same scope and size or larger within the last 6 years. Contractor shall demonstrate specific experience in regard to the system installation to be performed.

B. Welders: Submit the names of all qualified welders, their identifying symbols, and the qualifying procedures for each welder including support data such as test procedures used, standards tested to, etc. The welding of pressure piping systems shall be in accordance with qualifying procedures using performance qualified welders and operators. Structural members shall be welded in accordance with Section 05 50 00 - Miscellaneous Metals.

1.7 Delivery, Storage, and Handling

A. Materials delivered and placed in storage shall be stored with protection from the weather, excessive humidity variation, excessive temperature variation, dirt, dust and/or other contaminants.

B. Proper protection and care of material before, during and after installation is the Contractor's responsibility. Any material found to be damaged shall be replaced at the Contractor's expense.

C. During installation, piping shall be capped to keep out dirt and other foreign matter.

D. A material safety data sheet in conformance with 29 CFR 1910 Section 1200(g) shall accompany each chemical delivered for use in pipe installation. At a minimum, this includes all solvents, solvent cements, glues and other materials that may contain hazardous compounds. Handling shall be in accordance with ASTM F402. Storage facilities shall be classified and marked in accordance with NFPA 704. Materials shall be stored with protection from puncture, dirt, grease, moisture, mechanical abrasions, excessive heat, ultraviolet (UV) radiation damage, or other damage.

E. Pipe and fittings shall be handled and stored in accordance with the manufacturer's recommendation. Plastic pipe shall be packed, packaged and marked in accordance with ASTM D3892.

1.8 Project/Site Conditions

A. Existing Conditions

1. Verify existing piping and penetrations. Prior to ordering materials, expose all existing pipes which are to be connected to new pipelines. Verify the size, material, joint types, elevation, horizontal location, and pipe service of existing pipes, and inspect size and location of structure penetrations to verify adequacy of wall sleeves, and other openings before installing connecting pipes.

1.9 Sequencing and Scheduling

A. For slab, floor, wall, and roof penetrations, keep on site pertinent wall pipes and sleeves before they are required for placement in concrete forms. Verify and coordinate the size and location of building and structure pipe penetrations before forming and placing concrete.

Part 2 Products

2.1 Materials and Equipment

A. Provide piping materials and appurtenances as specified and as shown on the drawings, and suitable for the service intended.

B. Piping materials, appurtenances, and equipment supplied as part of this contract shall be of equal material and ratings as the connecting pipe, new and unused except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer. The general materials to be used for the piping systems are indicated by service in the contract drawings. Submit a list of piping systems, pressure ratings and source of supply for each piping system broken out by material, size and application as indicated on the contract drawings.

C. Pipe fittings shall be compatible with the applicable pipe materials.

D. Standard Products: Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacturing of the products and that essentially duplicate items that have been in satisfactory use for at least 5 years prior to bid opening. Nominal sizes for standardized products shall be used.

E. Identification and Tagging: Each piece of pipe shall bear the ASTM designation and all other markings required for that designation.

F. All materials in contact with potable water shall be certified to NSF Standard 61 and Standard 372.

2.2 Drains

A. Valved drains may not be shown on the detailed drawings for individual pipelines; their absence will not relieve the Contractor of the responsibility for providing and installing them as indicated in the piping and instrumentation diagrams to complete the piping system for the use intended.

B. Locations: Drains shall be located as indicated on the contract drawings.

C. Sizes: For pipelines 2.5 inch and larger, drains shall be 0.75 inch and equipped with ball valves. For pipelines 2 inch and smaller, drains shall be 1/2 inch and equipped with ball valves.

Part 3 Execution

3.1 Examination

A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Engineer of any discrepancy before performing the work.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

3.2 Preparation

A. Protection: Pipe and equipment openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.

B. System Preparation

1. Pipe and Fittings: Pipe and fittings shall be inspected before exposed piping is installed or buried piping is lowered into the trench. Clean the ends of pipes thoroughly, remove foreign matter and dirt from inside of pipes, and keep piping clean during and after laying.

2. Damaged Coatings: Repair damaged coating areas in the field with material equal to the original coating. Do not install damaged piping materials. Field repair of damaged and uncoated areas of galvanized piping shall conform to ASTM A780/A780M.

3. Field Fabrication: Notify the Engineer at least 2 weeks prior to the field fabrication of pipe or fittings and at least 3 days prior to the start of any surface preparation or coating application work.

C. Field welding shall be performed in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.3 for Pressure Piping, and as recommended by piping or fitting manufacturer. Welding electrodes shall be provided in accordance with Table 3.1 of AWS D1.1/D1.1M as required for the applicable base metals and welding process. Fabrication of fittings shall be performed in accordance with the manufacturer's instructions.

3.3 Exposed Piping Installation

A. Exposed piping shall be run as straight as practical along the alignment shown on the contract drawings and with a minimum of joints. Piping and appurtenances shall be installed in conformance with reviewed shop drawings, manufacturer's instructions and ASME B31.3. Piping shall be installed without springing or forcing the pipe.

B. Anchors and Fasteners: Impact expansion (hammer and explosive charge drive-type) anchors and fastener systems are not acceptable. Lead shields, plastic or fiber inserts, and drilled-in plastic sleeve/nail drive systems are also not acceptable.

1. Drilled-In Expansion Anchors and Fasteners:

a. The anchor/fastener assembly shall be UL listed with a one-piece stud (bolt) that has integral expansion wedges, nuts and washers. The stud shall be constructed of TP304 stainless steel, and nut and washer of TP304 stainless steel. The anchor length, diameter, and embedment depth shall meet the manufacturer's requirements for the maximum allowable working load of the application.

2. Drilled-In Adhesive Anchors: Drilled-in adhesive anchors shall not be used for overhead applications. The anchors shall be composed of an anchor rod assembly and an anchor rod adhesive cartridge. The anchor rod assembly shall be a chamfered and threaded stud rod of TP304 stainless steel with a nut and washer of TP316 stainless steel. The anchor length, diameter, and embedment depth shall meet the manufacturer's requirements for the maximum allowable working load of the application. The adhesive cartridge shall be a sealed capsule containing premeasured amounts of resin, quartz sand aggregate, and a hardener contained in a separate vial within the capsule. The capsule ingredients shall be activated by the insertion procedure of the anchor rod assembly.

3. Drilled-In Adhesive Anchors: Drilled-in adhesive anchors shall not be used for overhead applications. The anchors shall be composed of an anchor rod assembly and an anchor rod adhesive cartridge. The anchor rod assembly shall be a chamfered and threaded stud rod of TP304 stainless steel with a nut and washer of TP316 stainless steel. The anchor length, diameter, and embedment depth shall meet the manufacturer's requirements for the maximum allowable working load of the application. The adhesive cartridge shall be a sealed capsule containing premeasured amounts of resin, quartz sand aggregate, and a hardener contained in a separate vial within the capsule. The capsule ingredients shall be activated by the insertion procedure of the anchor rod assembly.

C. Piping Expansion and Contraction Provisions: The piping shall be installed to allow for thermal expansion and contraction resulting from the difference between installation and operating temperatures. Design for installation of plastic pipe exposed to ambient conditions or in which the temperature variation of the contents is substantial shall have provisions for movement due to thermal expansion and contraction documented to be in accordance with PPI TR-21. Anchors shall be installed as shown in the contract drawings to withstand expansion thrust loads and to direct and control thermal expansion. An intermediate pipe guide shall be installed for every pipe at each metal channel framing support not carrying an anchor or alignment guide. Where pipe expansion joints are required, pipe alignment guides shall be installed adjacent to the expansion device and within four pipe diameters. Expansion devices shall be installed in accordance with the manufacturer's instructions and at the locations shown in the contract drawings.

D. Piping Flexibility Provisions: Thrust protection shall be provided as required. Flexible couplings and expansion joints shall be installed at connections to equipment, and where shown on the contract drawings. Additional pipe anchors and flexible couplings beyond those shown on the contract drawings, shall be provided to facilitate piping installation, in accordance with reviewed shop drawings.

E. Couplings, Adapters and Service Saddles: Pipes shall be thoroughly cleaned of oil, scale, rust, and dirt in order to provide a clean seat for gaskets. Gaskets shall be wiped clean prior to installation. Flexible couplings and flanged coupling adapter gaskets shall be lubricated with [soapy water] [or] [the manufacturer's standard lubricant] before installation on the pipe ends. Couplings, service saddles, and anchor studs shall be installed in accordance with manufacturer's instructions. Bolts shall be tightened progressively, drawing up bolts on opposite sides a little at a time until all bolts have a uniform tightness. Torque-limiting wrenches shall be used to tighten bolts.

F. Piping Equipment/Component Installation: Piping components and indicators shall be installed in accordance with manufacturer's instructions. Required upstream and downstream clearances, isolation valves, and miscellaneous devices shall be provided for an operable installation. Provide union or flange at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal. Straight runs of piping upstream and downstream of flow measuring devices shall be as shown in the contract drawings.

G. Pipe Tap Connections: Taps to pipe barrels are unacceptable. Taps to ductile iron piping shall be made only with a service saddle or at a tapping boss of a fitting, valve body, or equipment casting. Taps to steel piping shall be made only with a welded threadolet connection.

H. Plastic Pipe Installation

1. Submit a statement signed by the plastic pipe manufacturer's representative certifying that the Contractor's personnel are capable of properly installing the piping system on the project. All plastic pipe shall be cut, made up, and installed in accordance with the pipe manufacturer's recommendations.

2. Heat joining shall be performed in accordance with ASTM D2657. Electrofusion joining shall be performed in accordance with ASTM F1290. Schedule 40 pipe shall not be threaded. Schedule 80 threaded nipples shall be used where necessary to connect to threaded valves or fittings. Strap wrenches shall be used for tightening threaded plastic joints, and care shall be taken not to over tighten these fittings.

3. Pipe shall not be laid when the temperature is below 40 degrees F, nor above 90 degrees F when exposed to direct sunlight. Any plastic pipe installed above grade and outdoors shall be ultraviolet (UV) protected or UV resistant.

4. The pipe ends that are to be joined shall be shielded from direct sunlight prior to and during the laying operation. Adequate ventilation shall be provided when working with pipe joint solvent cement and the handling of solvent cements, primers and cleaners shall be in accordance with ASTM F402.

5. PVC Piping: Solvent-cemented joints shall be constructed in accordance with ASTM D2855.

I. Piping Clearance, unless otherwise shown:

1. Over Walkway and Stairs: Minimum of 7 feet 6 inches, measured from walking surface or stair tread to lowest extremity of piping system, including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.

2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3 feet, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.

3. From Adjacent Work: Minimum 1 inch from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.

4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.

5. Headroom in front of openings, doors, and windows shall not be less than the top of the opening.

6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.

7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

3.4 Buried Pipe Placement

A. Excavation and Backfilling

1. Earthwork shall be performed as specified in Section 31 20 00 – Earth Moving and Section 31 23 33 – Trenching and Backfilling. Backfilling shall be accomplished after inspection by the Engineer. Exercise care when lowering pipe into the trench to prevent damage or twisting of the pipe.

B. Fittings

1. At valves and connections, the trench bottom shall be dug out with sufficient length, width, and depth to ensure clearance between the undisturbed trench bottom and the valves and such connections.

C. Thrust Restraint: Thrust restraint devices are generally not shown in the contract drawings; their absence will not relieve Contractor of the responsibility for providing them as required to provide complete systems for the use intended. Provide thrust blocks and ties where required, whether or not shown on the contract drawings. At a minimum, thrust restraint shall be provided at pipeline tees, plugs, caps, bends, and other locations where unbalanced forces exist.

1. Thrust Blocks: Thrust blocking shall be concrete of a mix not leaner than 1 cement, 2.5 sand and 5 gravel, and have a compressive strength of not less than 2000 psi after 28 days. Blocking shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and

thrust bearing sides of the thrust blocks shall be poured against undisturbed earth. The sides of thrust blocks not subject to thrusts may be poured against forms. The area of bearing shall be as shown or directed. Blocking shall be placed so that fitting joints shall be accessible for repair. Steel rods and clamps, protected by galvanizing or a coating of bituminous paint shall be used to anchor vertical down bends into gravity thrust blocks.

2. Restrained Joints: The restrained pipe length shall be as shown in the table on the drawings. Where restraint for particular fittings or conditions is not specified, restrained joints shall be designed by the Contractor or the pipe manufacturer in accordance with DIPRA TRD.

D. Marking Tape: Pipe marking tape shall be provided and installed in accordance with the requirements of Section 31 20 00 – Earthwork.

E. Plastic Pipe Installation

1. Plastic pipe shall be cut, fabricated, and installed in strict conformance with the pipe manufacturer's recommendations. Offset loops from the trench centerline shall be as recommended by the manufacturer for the maximum temperature variation between the pipe temperature at the time of solvent welding and operating temperature. Design for installation of plastic pipe exposed to ambient conditions or in which the temperature variation of the contents is substantial shall have provisions for movement due to thermal expansion and contraction documented to be in accordance with PPI TR-21. Flexible plastic pipe connected to heavy fittings, manholes, and rigid structures shall be supported in such a manner that no subsequent relative movement between the plastic pipe at the flanged joint and the rigid structures is possible.

3.5 Connecting Dissimilar Pipe

A. Flexible transition couplings, dielectric fittings and isolation joints shall be installed in accordance with the manufacturer's instructions.

3.6 External Corrosion Protection

A. Protect all pipe and piping accessories from corrosion and adverse environmental conditions.

B. Underground Metallic Piping: Buried metallic piping shall be protected from corrosion using protective coatings. Where dissimilar metals are joined underground, gas-tight isolation joints shall be used. Insulating joint material shall be provided where shown to control galvanic or electrical action.

C. Above Grade Metallic Piping:

1. Nonferrous and stainless steel piping shall not be painted. Where dissimilar metals are joined, isolation joints shall be used.

2. Ferrous Piping: Shop primed surfaces shall be touched up with ferrous metal primer. Surfaces that have not been shop primed shall be solvent cleaned.

Surfaces that contain loose rust, mill scale or other foreign substances shall be mechanically cleaned by commercial sand blasting conforming to SSPC SP 6/NACE No.3 and primed in accordance with Section 09 90 15. Primed surfaces shall be finished in accordance with Section 09 90 15.

3.7 Flexible Joints at Concrete Structures

A. Flexible joints shall be provided at the face of all structures, whether or not shown on the contract drawings. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints shall be considered flexible joints; welded pipe joints shall not. Joints may be flush with the structure face or may be located up to 1 pipe diameter away from face, but not further than 18 inches away from face.

3.8 Closures

A. Closure pieces shall be installed as necessary to end pipe runs and shall conform to ASME B16.9 or ASME B16.11. Elastomer sleeves bonded to pipe ends are not acceptable. Pressure piping shall have closures of butt-welded caps, blind flanges or threaded plugs with thickness matching the nominal wall thickness of the associated pipe, mounted on double flexible couplings, unless otherwise shown on contract drawings or approved by the Engineer. Pipes with restrained joints shall have pipe closures installed with thrust tie-rod assemblies as shown in contract drawings.

3.9 Penetrations

A. Steel pipe sleeves shall be hot-dipped galvanized after fabrication for above grade applications in non-submerged areas. For below grade, or in submerged and damp environments, steel pipe sleeves shall be lined and coated as specified in Section 09 90 15 - Paint. Embedded metallic piping shall be isolated from concrete reinforcement using coated pipe penetrations. Coatings shall be as specified in Section 09 90 15 - Paint. Wall pipes shall be securely supported by form work to prevent contact with reinforcing steel and tie-wires. Joints shall be sealed with a wall penetration seal. For existing concrete walls, rotary drilled holes may be provided in lieu of sleeves.

3.10 Pipe Identification, Painting and Color Coding

A. Color, coating, and lettering requirements for exposed piping shall be in accordance with Section 40 05 97 – Identification for Process Equipment.

3.11 Field Quality Control

A. Hydrostatic Tests: Where any section of a pipeline is provided with concrete thrust blocking for fitting, the hydrostatic tests shall not be made until at least 5 days after the installation of the concrete thrust blocking, unless otherwise approved by the Engineer.

B. Buried Piping: After the pipe is laid, the joints completed and the trench partially backfilled leaving the joints exposed for examination, the newly laid piping or any valved section of piping shall, unless otherwise specified, be subjected for 1 hour to a hydrostatic test pressure as listed in 40 23 00.10 – Piping Schedule. Each valve shall be opened and closed several times during the test. Exposed pipe, joints, fittings, and valves shall be carefully examined during the partially open trench test. Joints showing visible leakage shall be replaced as necessary. Defective pipe, joints, fittings, and valves found during the pressure test shall be removed and replaced with new material, and the test repeated until the test results are satisfactory. The requirement for the joints to remain exposed for the hydrostatic tests may be waived by the Engineer when one or more of the following conditions are encountered: (1) wet or unstable soil conditions in the trench; (2) compliance would require maintaining barricades and walkways around and across an open trench in a heavily used area that would require continuous surveillance to assure safe conditions; or (3) maintaining the trench in an open condition would delay completion of the Contract. The Contractor may request a waiver, setting forth in writing the reasons for the request and stating the alternative procedure proposed to comply with the hydrostatic tests. Backfill placed prior to the tests shall be placed in accordance with the requirements of Section 31 23 33 – Trenching and Backfilling.

C. Exposed Piping:

1. Hydrostatic testing shall be conducted in accordance with ASME B31.3. Piping systems shall be tested under normal service conditions (as indicated in the Pipe Schedule in the contract drawings) to demonstrate compliance. The test pressure shall not be less than 1.5 times the design pressure. Water shall be used as the hydrostatic test fluid. Provide clean test water of such quality to prevent corrosion of the piping system materials. Air release vents shall be opened at all high points of the piping system in order to purge air pockets while the piping system is filling.

2. For rigid piping hydrostatic testing, the maximum test pressure shall be calculated according to ASME B31.3, but shall not exceed the yield strength of the piping system. The maximum velocity during filling shall be 0.25 fps applied over the full area of pipe.

3. Test all parts of the piping system. The hydrostatic test pressure shall be maintained continuously for 30 minutes minimum and for such additional time as necessary to conduct examinations for leakage. All joints and connections shall be examined for leakage. The piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of leaking. Correct visible leakage and retest. Unless otherwise directed by the Engineer, the piping system shall be left full of water after leaks are repaired.

4. For non-rigid, non-metallic piping hydrostatic testing, the maximum test pressure shall be calculated according to ASME B31.3 but shall not exceed 1.5 times the maximum pressure rating of the lowest rated component in the piping system. The maximum velocity during filling shall be 0.25 fps applied over the full area of pipe. The system shall be initially pressurized to 50 percent of the normal service conditions and inspected. Any leaks shall be repaired by the Contractor. The system shall then be pressurized to the test pressure. Small amounts of water shall be added as required on an hourly basis for a maximum of 3 hours in order to maintain the test pressure. After 4 hours, the test

pressure shall be lowered by 10 psi. If the hydrostatic pressure remains steady for 1 hour, then no leakage is indicated. Inspect for leaks, repair and retest if necessary. The piping system shall be allowed to relax for 8 hours before retesting.

D. Time for Making Test: Except for joint material setting or where concrete thrust blocks necessitate a delay, underground piping jointed with rubber gaskets, mechanical or push-on joints, or couplings may be subjected to hydrostatic pressure, inspected, and tested for leakage at any time after partial completion of backfill. Tests for above ground pressure piping shall be conducted after the piping has been completely installed, including all supports, hangers, and anchors, and inspected for proper installation but prior to installation of insulation.

E. Pipe Leakage Tests

1. Unless approved by the Engineer, leakage testing shall be conducted after the pressure tests have been satisfactorily completed. The duration of each leakage test shall be at least 2 hours, and during the test the piping shall be subjected to not less than 200 psig. Leakage is defined as the quantity of water that is supplied to the piping system, or any valved or approved section thereof, in order to maintain pressure within 5 psi of the specified leakage test pressure after the piping has been filled with the test liquid and all air is expelled. No piping installation will be accepted if leakage exceeds the values listed in the Pipe Schedule in the contract drawings or, if applicable, the allowable leakage determined by the following formula:

$L = C_f \times N \times D \times P^{0.5}$
C_f = conversion factor = 0.0001351
L = allowable leakage, gallons per hour
N = number of joints in the length of piping tested
D = nominal pipe diameter, inches
P = average test pressure during the test, psig.

2. Should any test disclose leakage greater than that allowed, the leaks shall be located and repaired until the leakage is within the specified allowance, without additional cost.

3. Testing New to Existing Connections: New piping connected to existing pipe, existing equipment, existing treatment systems, or tanks and treatment systems furnished under other Sections shall be tested. Isolate the new piping with pipe caps, spectacle blinds, or blind flanges. The joint between new piping and existing piping shall be tested by methods that do not place the entire existing system under the test load. Proceed then, with the testing of new piping systems as specified herein.

3.12 Cleaning

A. Interim Cleaning: Prevent the accumulation of weld rod, weld spatter, pipe cuttings and filings, gravel, cleaning rags, and other foreign material within piping sections during fabrication. The piping shall be examined to assure removal of these and other foreign objects prior to assembly and installation.

B. Flushing: Following assembly and testing, and prior to final acceptance, piping systems shall be flushed with water to remove accumulated construction debris and other foreign matter. The piping shall be flushed until all foreign matter is removed from the pipeline. Provide all hoses, temporary pipes, ditches, and other items as required to properly dispose of flushing water without damage to adjacent properties. The minimum flushing velocity shall be 2.5 fps. For large diameter pipe where it is impractical to flush the pipe at the minimum flushing velocity, the pipeline shall be cleaned in-place from the inside by brushing and sweeping, then flushing the pipeline at a lower velocity. Cone strainers shall be installed in the flushing connections of attached equipment and left in place until cleaning is completed. Accumulated debris shall be removed through drains, or by removing spools or valves.

C. Disinfection

1. Disinfect all pipelines which will carry potable water, non-potable water, or hot water. Before acceptance of piping system operation, each section of completed pipeline shall be disinfected in accordance with AWWA C651. After pressure tests have been made, the piping section to be disinfected shall be thoroughly flushed with water until all entrained dirt and mud have been removed before introducing the chlorinating material. The chlorinating material shall be liquid chlorine, calcium hypochlorite, or sodium hypochlorite. The chlorinating material shall provide a dosage of not less than 50 ppm and shall be introduced into the piping in an approved manner. PVC pipelines shall be chlorinated using only the above specified chlorinating material in solution. In no case shall the agent be introduced into the line in a dry solid state. The treated water shall be retained in the pipe long enough to destroy all non-spore-forming bacteria. Except where a shorter period is approved, the retention time shall be at least 24 hours and shall produce not less than 25 ppm of free chlorine residual throughout the line at the end of the retention period. All valves on the lines being disinfected shall be opened and closed several times during the contact period. The line shall then be flushed with clean water until the residual chlorine is reduced to less than 1.0 ppm. During the flushing period, each outlet on the line shall be opened and closed several times. From several points in the pipeline section, Contractor personnel, approved by the Engineer, shall take samples in sterilized containers and have a bacterial examination performed by a commercial laboratory in accordance with state approved methods. The commercial laboratory must be certified by the state's approving authority for examination of potable water. The disinfection shall be repeated until the piping system passes the bacterial examination for 2 consecutive days. The piping system will not be accepted until satisfactory bacteriological results have been obtained.

3.13 Wastewater Disposal

A. Submit the method proposed for disposal of waste water from hydrostatic tests and disinfection, and all required permits, prior to performing hydrostatic tests. The water used for testing, cleaning, flushing and/or disinfection shall be disposed of in accordance with all applicable regulations. Disposal is solely the responsibility of the Contractor. The method proposed for disposal of waste water shall be provided to, and approved by, the Engineer prior to performing any testing, cleaning, flushing and disinfection activities.

3.14 Manufacturer's Field Services

A. Submit a signed statement certifying that the installation is satisfactory and in accordance with the contract drawings and specifications and the manufacturer's prescribed procedures and techniques, upon completion of the project and before final acceptance. Obtain manufacturer's technical assistance for Contractor training, installation inspection, start up, and owner operating and maintenance training. Follow manufacturer's instructions for installation.

END OF SECTION

Part 1 General

1.1 Work Included

A. The process and control system consist of the following:

1. Modifications and expansions to the plant SCADA Graphics and database.

2. Fiber optic and Radio telecommunications and SCADA network extensions.

3. Influent Pump Station

   a. Interface with the Screen Control Panels and provide interface to the plant SCADA system.

4. Building (Electrical Buildings A & B)

   a. Provide new control enclosures “RTU-1” and “RTU-2” with PLC controls, communications, I-O and hardened HMI interface in the electrical room in a NEMA 1 enclosure.

5. Modifications to existing I-O will require field verification and revision of existing loop drawings to meet the control narrative requirements and P&ID notations.

6. Due to the nature of equipment supplied in other specification sections, allow for minor changes in I-O list through the submittal process.

7. Install new isolation XFMRs for SCADA RTU’s in electrical buildings A & B (E-houses). Reuse the existing isolation XFMR’s for the existing SCADA RTU panels CP-0801 and CP-0802 to relocated to the Canopy area.

8. During the demolition of the existing Lower Poplar IPS building and adding two new temporary (Connex style) buildings (A & B) for temporary relocating the existing MCC-IPSA and existing VFDs (2, 4, 6 & 8) as shown on electrical demolition drawings to temporary building “A”, all SCADA I/O points will be maintained and operational during the demolition of the existing MCC-IPSB and VFDs (1, 3, 5 & 7).

9. MR Systems will provide and install a new SCADA RTU Cabinet in the temporary building “B” with all I/O points connected and programmed. The temporary SCADA RTU cabinet will remain operational during construction and will not be relocated from temporary building B until new electrical (e-house) building “A” is permanently installed and all new equipment (including SCADA) operational. At that time, the temporary SCADA RTU cabinet will be relocated from temporary building “B” to the new permanent electrical (e-house) building “B”.

B. Loop Descriptions.

C. Process Instrumentation Schedule.

1.2 Definitions

A. Definitions, Symbols, and engineering unit abbreviations shall conform to IEEE Standards Dictionary, as applicable.

1.3 Submittals

A. Submit in accordance with Section 01 33 23 – Shop Drawings, Product Data and Samples. Partial submittals will not be accepted.

B. Shop Drawings:

1. Bill of Materials: List of required equipment.

a. Group required equipment items by process area and enclosure, and within an enclosure as follows:

1) Process Control Components: By component identification code.

2) Other Equipment: By equipment type.

b. Data required:

1) Equipment tag number.

2) Description.

3) Manufacturer, complete model number, and all options not defined by model number.

4) Quantity supplied.

c. For control panels, include panel reference number and name plate inscription.

1) Catalog Cut Sheets: For all process controls components, electrical devices, and mechanical devices:

2) Catalog information, clearly marked to identify proposed items and options provided.

3) Descriptive literature.

4) External power and signal connections.

5) Scaled drawings showing exterior dimensions and locations of electrical and mechanical interfaces.

2. Component Data Sheets: For all process control components.

a. Format: Similar to ISA TR20.00.01. Submit proposed format for Component Data Sheets before completing data sheets for individual components. Submit in electronic format (Microsoft Excel compatible) with one component per data sheet.

3. Panel Construction Drawings:

a. Scale Drawings: Show dimensions and locations of panel-mounted devices, doors, and subpanels, both internal and external.

b. Panel Legend (Bill of Materials): List front of panel devices by tag numbers, nameplate inscriptions, and service legends.

c. Bill of Materials: List devices mounted within panels which are not listed in panel legend. Include tag number, description, manufacturer, and model number.

d. Construction Details: NEMA rating, materials, lifting lugs, mounting brackets and tabs, door hinges and latches, and welding and other construction callouts and details.

e. Construction Notes: Finishes, wire color schemes, wire ratings, wire, terminal block numbering, and labeling scheme.

4. Panel Wiring Diagram:

a. Cover wiring within a panel including, but not limited to, instrumentation, control, power, communications, and digital networks. Provide information for wiring panels, making panel connections, and future panel trouble shooting.

b. Diagram Type:

1) Ladder diagrams where applicable. Include devices that are mounted in or on the panel that require electrical connections. Show unique rung numbers on left side of each rung.

2) Schematic drawings for wiring of circuits that cannot be well represented by ladder diagrams.

3) Item identification: Identify each item with attributes as listed below.

4) Wires: Wire number and color. Cable number if part of a multi-conductor cable.

5) Terminals: Location (enclosure number, terminal junction box number, or MCC number), terminal strip number, and terminal block number.

6) Components

a) Tag number, terminal numbers, and location (“FIELD”, enclosure number, or MCC number).

b) Switching action (open or close on rising or falling process variable), setpoint value and units, and process variable description.

7) I/O Points: PLC unit number, I/O tag number, I/O address, terminal numbers, and terminal strip numbers.

8) Relay Coils:

a) Tag number and its function.

b) On right side of run where coil is located, list contact location by ladder number and sheet number. Clearly indicate normally closed contacts.

9) Relay Contacts: Coil tag number, function, and coil location (ladder rung number and sheet number).

10) Communications and Networks: Network type, address or node identification, port or channel number, and type of connector.

11) Show each circuit individually. No “typical” diagrams or “typical” wire lists will be allowed.

12) Wire and Cable Names: Show names and wire colors for circuits entering and leaving a panel.

5. Loop Wiring Diagrams: Individual, end-to-end wiring diagram for each analog, discrete, or equipment loop.

a. Conform to requirements of ISA S5.4.

b. Show loop components within a panel and identify each component, component terminals, and panel terminals.

c. If a loop connects to panels or devices not provided under this Section and its related sections, such as control valves, motor control centers, package system panels, and variable speed drives, provide the following information:

d. Show the first component connected to within the panel or device that is not provided under this Section and its subsections.

e. Identify the component by tag and description.

f. Identify panel and component terminal numbers.

g. Provide one drawing per I/O module. Show all PLC I/O. No “typical” loop diagrams will be allowed.

h. Show:

1) Terminal numbers, location of dc power supply, and location of common dropping resistors.

2) Switching contacts in analog loops and output contacts of analog devices. Reference specific control diagrams where functions of these contacts are shown.

i. Tabular summary on each analog loop diagram:

1) Transmitting Instruments: Output capability.

2) Receiving Instruments: Input impedance.

3) Loop wiring impedance: Estimate based on wire sizes and lengths shown.

4) Total loop impedance.

5) Reserve output capacity.

j. Circuit and raceway schedule names.

k. Drawing Size: Individual 22-inch by 34-inch sheet.

6. Communications Networks Diagrams:

a. Include connections to Ethernet and Fiber Optic network.

b. Network schematic diagrams for each different type of network.

c. Show:

1) Interconnected devices, both passive and active.

2) Device names and numbers.

3) Terminal numbers.

4) Communication Media: Type of Cable.

5) Connection Type: Type of connector.

6) Node and device address numbers.

7) Wire and cable numbers and colors.

7. Panel Power Requirements and Heat Dissipation: For control panels, tabulate and summarize:

a. Required voltages, currents, and phases.

b. Maximum heat dissipation in Btu per hour.

c. Steady State Temperature Calculations: For non-ventilated panels, provide heat load calculations showing the panel estimated internal steady state temperatures for ambient air temperatures of 85 degrees F.

8. Panel Plumbing Diagrams: For each panel containing piping and tubing. Show type and size for:

a. Pipes and tubes: Thickness, pressure rating, and materials.

b. Components – valves, regulators, and filters.

c. Connections to panel-mounted devices.

d. Panel interface connections.

e. Installation Details: Include modifications or further details required to define installation of process control components.

9. List of Spares, Expendables, and Test equipment.

10. PLC I/O List.

1.4 Informational Submittals:

A. Statements of Qualifications

1. Instrumentation and Controls Subcontractor’s site representative.

2. Resume for each member of system integrator’s onsite startup and testing team (engineers, technicians, and software configuring personnel).

B. Operation and Maintenance Data: In accordance with Section 01 78 23 and the following:

1. General: Provide sufficient detail to allow operation, removal, installation, adjustment, calibration, and maintenance and purchasing replacements for process control components.

2. Include the following items as defined above:

    a. Bill of materials.

    b. Catalog cut sheets.

    c. As-built Detailed Wiring Diagrams:

    d. Panel wiring diagrams.

    e. Loop diagrams.

    f. Panel Plumbing Diagrams.

    g. Application software documentation.

    h. Manufacturer's O&M manuals for components, electrical devices, and mechanical devices.

    i. List of spares, expendables, test equipment and tools provided.

    j. List of additional recommended spares, expendables, test equipment, and tools. Include quantities, unit prices, and total costs.

C. Testing Related Submittals:

1. Performance Verification Test (PVT) Factory Test Procedure

    a. Proposed test procedures, forms, and checklists.

    b. Capacity, Timing, and Simulation: Describe simulation and monitoring methods used to demonstrate compliance with capacity and timing requirements.

2. Factory Test Reports for Testing, Adjusting and Commissioning Performance Verification Test (PVT) and Endurance Test.

3. Equipment Communications Test:

    a. Test procedures, forms, and checklists.

    b. Test reports.

4. Component Acceptance Test:

    a. Test procedures, forms, and checklists.

b. Test reports.

5. Closeout Submittals

a. Operation and maintenance data:

b. Operating and applications software documentation.

c. Software licenses.

d. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard- copy submittal.

6. Software and Firmware Operational Documentation:

a. Software operating and upgrade manuals.

b. Software Backup: On a magnetic media or compact disc, complete with Owner-selected options.

c. Device address list and the set point of each device and operator option, as set in applications software.

1.5 Site Environmental Conditions

A. Capacity and design of the air moving equipment and accessories shall be suitable for 24-hour full load service and shall meet the following criteria noted from the 2021 ASHRAE Handbook – Fundamentals for the location of Middle Georgia, GA..

B. Location

Altitude	343 ft

C. Winter Design Temperatures

Outside Air	23.7 degrees F
Inside Air Temperature	55 degrees F

D. Summer Design Temperatures

Outside Air	96.7 degrees F
Inside Air Temperature	85 degrees F

1.6 Field Training

A. Field training oriented to the specific system shall be provided for designated personnel.

B. Furnish a copy of the training manual for each trainee plus two additional copies.

C. Manuals shall include an agenda, the defined objectives for each lesson, and a detailed description of the subject matter for each lesson.

D. Furnish audiovisual equipment and other training supplies and materials. Copies of the audiovisuals shall be delivered with the printed training manuals.

E. A training day is defined as 8 hours of classroom instruction, excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

F. Submit the training manual and schedule to receive approval from the Engineer at least 30 days before the training.

G. Preliminary Operator Training

   1. Prior to the start of field testing, preliminary operator training shall be taught at the project site for 2 consecutive training days.

   2. Upon completion of this course, each student, using appropriate documentation, should be able to perform elementary operations with guidance and describe the general hardware architecture and functionality of the system.

   3. This course shall include: general system architecture; functional operation of the system, including workstations; operator commands; application programs, control sequences, and control loops; database entry and modification; reports generation; alarm reporting; diagnostics; and historical files.

H. Additional Operator Training

   1. Following the field testing, additional classroom training for operators shall be taught for 2 consecutive training days.

   2. Individual instruction shall consist of "hands-on" training under the constant monitoring of the instructor.

   3. Classroom training shall include instruction on the specific hardware configuration of the installed control system and specific instructions for operating the installed system.

   4. Schedule activities during this period so that the specified amount of time on the equipment will be available for each student.

   5. The final session will address specific topics that the students need to discuss and to answer questions concerning the operation of the system.

   6. Upon completion of the course, the students should be fully proficient in system operation and have no unanswered questions regarding operation of the installed control system.

7. Each student should be able to start the system, operate the system, recover the system after a failure and describe the specific hardware architecture and operation of the system and be fully proficient in all system operations.

8. Report the skill level of each student at the end of this course.

I. Maintenance Training

1. Following the endurance test, a minimum period of five training days shall be provided by a factory representative or a qualified Contractor trainer for ten designated personnel on maintenance of the equipment.

2. The training shall include: physical layout of each piece of hardware, calibration procedures, preventive maintenance procedures, schedules, troubleshooting, diagnostic procedures and repair instructions.

Part 2 Products

2.1 System Description

A. The process instrumentation and control system shall be used to monitor and control the operation of process equipment as specified and in accordance with the sequence of control and control schematics shown on the drawings. The control system shall provide for operator interaction, overall control system supervision, and process equipment control and monitoring.

B. Provide hardware configured and sized to support expansion as specified and shown on the drawings.

C. Instrumentation Schedule: See Tables Following this Section.

D. Operation

1. The control system provided under this specification shall operate using direct digital control (DDC) algorithms or ladder logic type and supervisory control to provide the required sequences of operation.

2. Input data to the controller shall be obtained by using instruments and controls interfaced to mechanical, electrical, utility systems and other systems as shown and specified.

3. The number and location of control panels shown on drawings shall be provided as a minimum.

E. Points

1. Each connected analog output (AO), analog input (AI), digital output (DO), digital input (DI), pulse accumulator (PA) input and other input or output

device connected to the control system shall represent a "point" where referred to in this specification.

F. Data Transmission Systems (DTS)

1. Provide data transmission systems for communication between PLCs and the central station as specified in Section 26 05 23 – Control Voltage Electrical Power Cables and as indicated.

2.2 Materials And Equipment

A. Standard Products: Materials and equipment must be standard unmodified products of a manufacturer regularly engaged in the manufacturing of such products. Units of the same type of equipment shall be products of a single manufacturer. Items of the same type and purpose shall be identical and supplied by the same manufacturer, unless replaced by a new version approved by the Engineer.

B. Nameplates:

1. Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place.

2. Laminated plastic nameplates shall be provided for equipment devices and panels furnished. Each nameplate shall identify the device, utilizing the designations shown on the P&ID’s, such as pump "P-1001" or valve "V-0012".

3. Labels shall be coordinated with the schedules and the process and instrumentation drawings.

4. Laminated plastic shall be 1/8 inch thick, white with black center core.

5. Nameplates shall be a minimum of 1 by 3 inches with minimum 1/4 inch high engraved block lettering.

6. Nameplates for devices smaller than 1 by 3 inches shall be attached by a nonferrous metal chain. All other nameplates shall be attached to the device.

2.3 General Requirements

A. Equipment located outdoors, not provided with climate-controlled enclosure, shall be capable of operating in the ambient temperature range indicated in paragraph ENVIRONMENTAL CONDITIONS, unless otherwise specified.

B. Electrical equipment will conform to Division 26. Equipment and wiring must be in accordance with NFPA 70, with proper consideration given to environmental conditions such as moisture, dirt, corrosive agents, and hazardous area classification.

2.4 Monitoring And Control Parameters

A. The control system shall be complete including sensors, field preamplifiers, signal conditioners, offset and span adjustments, amplifiers, transducers, transmitters, control devices, engineering units' conversions and algorithms for the applications; and shall maintain the specified end-to-end process control loop accuracy from sensor to display and final control element.

B. Control equipment shall be powered by a 120 V ac, single phase, 60 Hz power source, with local transformers included as needed for signal transmission and subsystem operation.

C. Connecting conductors shall be suitable for installed service.

2.5 Control Panels (Including RTU Cabinets)

A. Components

1. UL listing mark for enclosures: mark panels stating, "Listed Enclosed Industrial Control Panel" per UL 508A.

2. Enclosures: The enclosure for each control panel shall conform to the requirements of NEMA 250 for the types specified. Finish color shall be the manufacturer's standard, unless otherwise indicated. Damaged surfaces shall be repaired and refinished using original type finish. Enclosures for installation in mechanical equipment rooms shall be Type 4; those for installation in clean, dry indoor occupied space may be Type 1; other locations shall be as otherwise specified or shown. Enclosures for installation outdoors or in a corrosive environment shall be Type 4X and shall be constructed of stainless steel. Painted steel shall not be allowed for use in a corrosive environment. Enclosure shall be provided with a single, continuously hinged exterior door with print pocket, 3-point latching mechanism and key lock and a single, continuously hinged interior door.

3. Standard Indicator Light: Indicator lights shall comply with NEMA ICS 1, NEMA ICS 2 and UL 508. Lights shall be heavy duty, round and shall mount in a 0.875 inch mounting hole. Indicator lights shall be LED type and shall operate at 120 V ac or 24 V dc. Indicator light shall be provided with a legend plate labeled as shown on the drawings. Lens color shall be as indicated on the drawings.

4. Selector Switches: Selector switches shall comply with NEMA ICS 1, NEMA ICS 2 and UL 508. Selector switches shall be heavy duty, round and shall mount in a 0.875 inch mounting hole. The number of positions shall be as indicated on the drawings. Switches shall be non-illuminated or as indicted of the drawings. Switches shall be rated for 600 volts, 10 amperes continuous. Selector switches shall be provided with a legend plate labeled as shown on the drawings. Where indicated or required, dual auxiliary contacts shall be provided for the automatic position to provide position sensing at the central

station or workstation. Auxiliary contacts shall be rated for 120 V ac, 1A as a minimum. Where indicated on the drawings, switches shall be key operated. All keys shall be identical.

5. Push Buttons: Push buttons shall comply with NEMA ICS 1, NEMA ICS 2 and UL 508. Push buttons shall be heavy duty, round and shall mount in a 0.875 inch mounting hole. The number and type of contacts shall be as indicated on the drawings or required by the Sequence of Control. Push buttons shall be rated for 600 volts, 10 amperes continuous. Push buttons shall be provided with a legend plate labeled as shown on the drawings.

6. Relays: Relays shall comply with IEEE C37.90. Relays shall be as required by the Sequence of Control]. Relay coil shall be provided with matching mounting socket. Power consumption shall not be greater than 3 watts.

7. Terminal Blocks: Terminal blocks shall comply with NEMA ICS 4 and UL 1059. Terminal blocks for conductors exiting control panels shall be two-way type with double terminals, one for internal wiring connections and the other for external wiring connections. Terminal blocks shall be made of bake lite or other suitable insulating material with full deep barriers between each pair of terminals. A terminal identification strip shall form part of the terminal block and each terminal shall be identified by a number in accordance with the numbering scheme on the approved wiring diagrams.

8. Alarm Horns: Alarm horns shall be provided where indicated on the drawings. Horns shall be vibrating type and shall comply with UL 508. Horns shall provide 100 dB at 10 feet. Exterior mounted horns shall be weatherproof by design or shall be mounted in a weatherproof enclosure that does not reduce the effectiveness of the horn.

B. All control panels shall be dead-front style. Switches, pushbuttons, indicator lights, and the HMI panels shall be mounted to the inside dead-front panel. Do not mount any equipment to the panel exterior door.

C. Panel Assembly: Control panels shall be factory assembled and shipped to the jobsite as a single unit. Panels shall be fabricated as indicated and devices shall be mounted as shown or required. Each panel shall be fabricated as a bottom-entry connection point for control system electrical power, control system main air source, control system wiring, control air pneumatic tubing, communications system wiring to other control panels.

D. Electrical Requirements: Each panel shall be powered by a dedicated 120 volts ac circuit, with a fuse, sized as recommended by the equipment manufacturer, and a disconnect switch located inside the panel. Wiring shall terminate inside the panel on terminal blocks. Electrical work shall be as specified in Division 26 and as shown on the drawings.

1. Wiring within enclosures:

a. For AC Circuits:

1) 600V, Type MTW stranded copper

2) Size: for current to be carried, but not less than #14 AWG.

b. For analog signal circuits:

1) 300V, type 2 stranded copper, twisted shielded pairs.

2) Size: #18 AWG minimum.

c. For DC Circuits:

1) 600V, Type MTW stranded copper

2) Size: #18 AWG minimum.

d. Separate analog signals and other DC circuits at least 6 inches away from AC power wiring.

e. Enclosure wiring in sheet metal raceways or plastic wiring ducts.

2. Wire Identification: per section 26 05 53.

3. Wiring Interface:

a. For analog and discrete signals, terminate wiring at numbered terminal blocks.

b. For special signals, terminate power (240 volts or greater) at manufacturer's standard connectors.

c. For panels, terminate wiring at equipment on/with which it is mounted.

4. Terminal Blocks:

a. Quantity:

1) Sufficient for all external connections, plus minimum 20 percent spare, but not less than 1.

2) Wire spare or unused panel mounted elements to their panels' terminal blocks.

b. General: Group terminals to keep 120V AC circuits separate from 24V DC circuits.

c. Connection Type: Screw connection clamp.

d. Compression Clamp: Hardened steel clamp with transversal grooves penetrating wire strands providing a vibration-proof connection. Compression clamp guides strands of wire into terminal.

e. Screws: Hardened steel, captive, and self-locking.

f. Grounding Bar: Copper.

g. Insulation: Insulation shall be thermoplastic rated for minus 55 to plus 110 degrees C. Provide two funnel shaped inputs to facilitate wire entry.

h. Mounting:

1) Rail.

2) Terminal block shall be designed to be extracted from an assembly without displacing adjacent blocks.

3) End Stops: Provide one at each end of rail, minimum.

i. Wire Preparation: Stripping only.

j. Jumpers: Allow jumper installation without loss of space on terminal or rail.

k. Marking System:

1) Terminal number shown on both sides of terminal block.

2) Allow use of preprinted and field marked tags.

3) Terminal strip numbers shown on end stops.

4) Mark terminal block and terminal strip numbers as shown.

5) Manufacturer: Weidmueller, Phoenix Contact (or approved equal)

5. Power Supplies:

a. Furnish as required to power instruments requiring external DC power, including two-wire transmitters and DC relays.

b. Convert 120 V AC, 60-Hz power to DC power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.

c. Provide output over-voltage and over-current protective devices to:

d. Protect instruments from damage due to power supply failure.

e. Protect power supply from damage due to external failure.

6. Power Line Conditioner: Each control panel shall be provided with a power line conditioner to provide both voltage regulation and noise rejection. The power line conditioner shall be of the ferro-resonant design, with no moving parts and no tap switching, while electrically isolating the secondary from the power line side. The power line conditioner shall be sized for 125 percent of the actual connected kVA load. Characteristics of the power line conditioner shall be as follows:

   a. 85 Percent Load: At 85 percent load, the output voltage shall not deviate by more than plus or minus 1 percent of nominal voltage when the input voltage fluctuates between minus 20 percent to plus 10 percent of nominal voltage.

   b. Load Changes: During load changes of zero to full load, the output voltage shall not deviate by more than plus or minus 3 percent of nominal voltage. Full correction of load switching disturbances shall be accomplished within 5 cycles, and 95 percent correction shall be accomplished within 2 cycles of the onset of the disturbance.

7. Grounding:

   a. Control panel enclosures shall be equipped with a solid copper ground bus or equivalent. The ground bus shall be securely anchored to the enclosure to effectively ground the entire structure. Clamp-type terminals sized large enough to carry the maximum expected current shall be provided on the ground bus for grounding cables. Where a definite circuit ground is required, a single wire not less than #10 AWG shall run independently to the panel ground bus and shall be fastened to the ground bus with a bolted terminal lug.

   b. Cases of instruments, relays and other devices shall be effectively grounded through the enclosures steel structure unless otherwise indicated. Insulated wiring having a continuous rated current of not less than the circuit fuse rating shall be used for grounding.

   c. Grounding terminals of power receptacles shall be solidly grounded to the panel enclosure.

8. Convenience Outlet

   a. A 120-volt ac, 20 amp, ground fault interruption (GFI) type duplex convenience outlet shall be provided inside the panel. The outlet circuit shall be separate from the panel power circuit.

9. Panel Interior Light: Each control panel(s) shall be provided with an LED light. The light shall be operated by a manual on-off switch mounted on the interior door of the enclosure. The light shall be powered by the same circuit as the convenience outlet.

10. Ventilation System: Each control panel(s) shall be provided with two single phase, 120-volt ac ventilation fans. Each fan shall supply a minimum of 100 cfm of ventilation air through the enclosure. Each fan shall be provided with a line voltage thermostat. Thermostat setpoints shall be adjustable in a range of 70 to 140 degrees F as a minimum. Each supply and exhaust grille shall contain a filter that is easily removed for cleaning or replacement.

11. Heating System: Where indicated, control panel(s) shall be provided with a thermostatically controlled electric heater capable of maintaining an enclosure temperature of 55 degrees F when continuously exposed to an ambient temperature of 32 degrees F.

12. Air Conditioning System: Where indicated, control panels shall be provided with a mechanical refrigeration air conditioning system. The system shall be capable of maintaining a temperature of 100 degrees F inside the enclosure with all equipment in the panel operating and while continuously exposed to full sunlight and an ambient air temperature of 90 degrees F. The compressor and condenser shall be located outside the control panel enclosure. Provisions shall be made to remove condensate from the control panel and to protect all devices within the enclosure from condensate.

13. Uninterruptible Power Supply (UPS)

    a. A self-contained UPS suitable for installation and operation at each RTU cabinet shall be provided. The unit[s] shall be sized to provide a minimum of 10 minutes of operation of the central station computer. The UPS shall incorporate surge suppression, noise filtering (normal and common mode) short circuit protection and voltage regulation (brownout and overvoltage protection).

    b. UPS shall be complete with all necessary power supplies, transformers, batteries, and accessories and shall include visual indication of normal power operation, UPS operation, abnormal operation, and visual and audible indication of low battery power. The UPS shall comply with the Federal Communications Commission Standard 15J part A for radio noise emissions.

14. Communication and Programming Device: A hand-held communication and programming device shall be provided. The communication and programming device shall connect to the PLC directly for readout of variables, override, control, servicing, troubleshooting and adjustment of control parameters. The device shall be provided with all necessary cables, connectors, and adapters to allow connection to the PLC. The device shall communicate in English language for inquiry, reporting and programming purposes.

2.6 Programmable Logic Controller (PLC) System

A. General

1. Function: PLC configured to provide communications between PLC and workstation. Also, capable of logic functions such as relays, timers, counters, current switches, calculation modules, PID controllers, stepping switches, and drum programmers.

2. Type: Microprocessor based device programmable using ladder logic.

3. Central Processing Unit (CPU), power, supply, local and remote (if required) input/output modules, local and remote (if required), base controller, programming software and adapter modules, and factory assembled interconnecting cables. Provide components required to make a complete and totally operational system.

B. Power Supply

1. One unit for each input/output base assembly:

2. Voltage: 120 volts, 60 hertz; 85 to 132 volts output.

3. Mounting: Integral with base.

C. Input/Output

1. Complete input/output system

2. Modular, block type.

D. Identification

1. Nameplates installed above each PLC component (CPU, I/O rack, power supply, etc.)

2. Identify configured I/O points as they have been configured (addressed) in the system, as approved by the Engineer.

E. Programming Computer and Software

1. Use programming computer supplied as part of the project. Load programming software and provide all modules and ancillaries to make a completely operating system. Include all software and cables required for programming of PLC’s.

F. Manufacturers and Products – PLC’s

1. Design is based on the following PLC’s. These are provided to convey the level of quality required of the system, as well as the capabilities.

a. Schneider Electric

b. ABB

c. Allen-Bradley, CompactLogix

2. Cables

a. CAT6E cables shall be plenum rated and contain 4 pairs.

b. Fiber Optic cables shall have an overall polyamide jacket.

3. Ethernet Switches

a. Full duplex.

b. 100 MBIT/S

1) 100 Base-FX (Fiber)

2) 100 Base-TX (Copper)

a) Industrial Rated

2.7 Touch Screens

A. General

1. A color touch screen shall be mounted flush to the face of the control panel.

2. Touch screens shall be a minimum of 15 inches (diagonally measured).

3. Memory shall be a minimum of 128 MB RAM, 128 MB CF.

4. Resolution shall be a minimum of 1024 x 768.

5. Backlights shall be field replaceable (unless LED backlighting is used).

6. Touch screens shall be stand alone. All screens and programming shall reside on it.

7. Platform shall be open multi-application.

B. Electrical

1. Input Voltage: 120 V ±10 percent.

2. Power Consumption: 200 VA maximum.

2.8 HMI Application Software Design Criteria

A. The package system supplier shall develop the HMI application software to convey accurate information to the plant operations staff to facilitate monitoring of the package system status, informed process control decisions, and provide the platform to execute the control decisions.

B. The following outlines key objectives in designing the package system HMI application graphics displays:

1. Easily navigated menus.

2. Maintain consistency in graphic display and controls design.

3. Provide accurate representation of the package control system and its operations.

4. Develop help screens to provide additional information to help the operations staff understand the control options where complex operations are required.

5. Provide operator access with security levels.

6. Graphic Screen Colors:

a. Red: Equipment STOPPED or Valve CLOSED.

b. Green: Equipment RUNNING or Valve OPENED.

c. Amber: Alarm Condition.

2.9 Plant SCADA DCS Network Plant Network

A. The existing radio and antenna for the IPS building shall be relocated and connect to the PLC/RTU control panel. This is the main communication to the plant SCADA system.

B. Provide managed gigabit Ethernet switches by Cisco or approved equal for connection between PLC/RTU/HMI panels. Network switches shall include a minimum of (2) two fiber SFP ports and (8) eight RJ-45 ports.

C. Provide fiber optic patch panels for single mode, 12-count fiber optic cables with LC- connections.

D. Provide patch cables as required and 25% spare.

E. Provide overall network architecture compatible with existing.

2.10 DCS Network Interface

A. General:

1. DCS remote I-O shall communicate with the plant SCADA and HMI computers.

2. Where noted, DCS remote I-O and HMI communications shall be via the plant Ethernet I/P control system network.

B. Data Exchange:

1. Provide network communication failure monitoring and detection with a “heartbeat” signal.

2. Organize data values to be exchanged into contiguous register blocks. One block for each of the following types:

a. Analog data to be sent.

b. Analog data to be received.

c. Discrete data to be sent.

d. Discrete data to be received.

3. Format for Analog Values: Engineering units using double precision floating point format.

4. Format for Discrete Values: 16-bit binary words (representing 6 unique status or alarm conditions).

C. Coordination and Testing:

1. Provide dedicated time for coordinating final data point definitions with the Owner’s System Integrator.

2. Provide onsite testing and startup time devoted to data exchange testing, message validation, and network timing validation with control packages of equipment.

2.11 DCS Cp I/O List And Tag Names

A. Provide an input/output (I/O) list for each CCP with the following columns:

1. Description: A description of each I/O point.

2. I/O Type: Choice of Analog Input (AI), Analog Output (AO), Digital Input (DI), Digital Output (DO).

3. Low (0 Percent): The 0 percent engineering unit value for an analog signal; 0 or 1 for a discrete signal denoting polarity (standard for a DI would 0).

4. High (100 Percent): The 100 percent or full span engineering unit value for an analog signal; 0 or 1 for a discrete signal denoting polarity (standard for a DI would be 1).

5. ENG Units: Example gpm, FT, MGD, SCFM, psi, Deg F, A, V, W, VA.

6. CP Number: CP reference number (two characters).

7. Facility Number (two characters).

8. Loop Number: A three-character number defining the loop number.

9. Sequential Number: A two-character number defining the device number.

10. ISA ID: The three-character ISA identifier.

11. Tag Suffix: A tag suffix if the signal is a digital signal (or analog signal if the loop number does not change in a particular unit).

12. Tag Name: Tag name for each I/O point.

13. I/O Name: The point ADDRESS in the DCS Database.

14. Chassis Slot: Slot the I/O point is terminated.

15. Point Number: I/O point number.

16. Comments: Reserved for special instructions.

B. Network I/O Points:

1. Assign I/O tag names and provide a listing of I/O points that are communicated via the Ethernet networks.

2. Identify network I/O point types as follows: Analog Input (NAI), Analog Output (NAO), Digital Input (NDI), Digital Output (NDO).

2.12 Instrument Tag Numbers

A. Use Project standard format as defined in Instrumentation and Control Legend.

1. For example: PIT-1021

Notation	Explanation
PIT	ISA designator for Pressure Indicating Transmitter
10	Facility Number
21	Sequence Number

2.13 Data Communication Requirements

A. Control system data communications shall support the specified functions and control system configuration shown on the drawings.

2.14 Factory Test

A. The control system shall be tested at the factory prior to shipment. Written notification of planned testing shall be given to the Engineer and Owner at least 21 days prior to testing, and in no case shall notice be given until after the Contractor has received written approval of the test procedures.

B. Factory Test Setup

1. Assemble and integrate the factory test setup as specified to prove that performance of the system satisfies all requirements of this project, including system communications requirements in accordance with the approved test procedures.

2. The factory test shall take place during regular daytime working hours on weekdays.

3. Equipment used shall be the same equipment that is to be delivered to the site.

4. The factory test setup shall include the following:

Factory Test	
Control Panel	not less than two control panels: at least one of each type used in the system plus at least one per DTS type
Test Set	one of each type
Portable Tester	one of each type
Communications Circuits	one of each type and speed to be utilized in the proposed system including bridges, modems, encoder/decoders, transceivers and repeaters
Surge Protection Equipment	for power, communications, I/O functions and networks
I/O functions	sufficient to demonstrate the I/O capability and system normal operation
Software	software required for proper operation of the proposed system including application programs and sequences of operation

C. Factory Test Procedure

1. Test procedures shall define the tests required to ensure that the system meets technical, operational, and performance requirements.

2. The test procedures shall define location of tests, milestones for the tests, and identify simulation programs, equipment, personnel, facilities, and supplies required.

3. Provide for testing all control system capabilities and functions specified and shown.

4. Cover actual equipment and sequences to be used for the specified project and include detailed instructions for test setup, execution, and evaluation of test results.

5. The test reports shall document results of the tests.

6. Surge testing need not be conducted if acceptable documented proof can be provided that such testing has been satisfactorily demonstrated with identical surge protection applied.

The procedures shall include the following:

	Test Procedure
Equipment	block diagram
hardware and software	Descriptions
Commands	operator commands
I/O functions	test database points with failure modes
Passwords	required for each operator access level
each type of digital and analog point in the test database	Description
test equipment	List
surge protection	circuit diagrams
inputs required (I/O point values and status) and corresponding expected results of each set of input values	for each application program
default values	for the application program inputs not implemented or provided for in the contract documents for the application programs to be tested

D. Factory Test Report: Submit original copies of data produced during the factory test, including results of each demonstration procedure within 7 days after completion of each test. Arrange the report so that commands, responses, and data acquired are correlated to allow logical interpretation of the data.

Part 3 Execution

3.1 Examination

A. Verify the following conditions for all equipment not provided by process instrumentation subcontractor, but which interfaces with process control system:

1. Proper installation.

2. Calibration and adjustment of positioners and transducers.

3. Correct control action.

4. Switch settings and dead bands.

5. Opening and closing speeds and travel stops.

6. Input and output signals.

3.2 Equipment Installation Requirements

A. Installation

1. Install system components and appurtenances in accordance with the manufacturer's instructions and provide necessary interconnections, services, and adjustments required for a complete and operable system. Adjust or replace devices not conforming to the required accuracies.

2. Replace factory sealed devices, rather than adjusting.

3. Install instrumentation and communication equipment and cable grounding as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.

4. Install wiring in exposed areas, including low voltage wiring, in metallic raceways as specified in Section 26 05 53 – Raceways and Boxes for Electrical Systems. Wiring in air plenum areas installed without conduit shall be plenum-rated in accordance with NFPA 70.

5. Submit detail drawings containing complete piping, wiring, schematic, flow diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Include in the Drawings, as appropriate: product specific catalog cuts; a drawing index; a list of symbols; a series of drawings for each control system using abbreviations, symbols, nomenclature and identifiers as shown; valve schedules; compressed instrument air station schematics and ASME air storage tank certificates for each type and make of compressed instrument air station.

B. Isolation, Penetrations and Clearance from Equipment

1. Dielectric isolation shall be provided where dissimilar metals are used for connection and support.

2. Penetrations through and mounting holes in the building exteriors shall be made watertight.

3. Holes in concrete, brick, steel and wood walls shall be drilled or core drilled with proper equipment; conduits installed through openings shall be sealed with materials which are compatible with existing materials.

4. Openings shall be sealed with materials which meet the requirements of NFPA 70.

5. Installation shall provide clearance for control-system maintenance.

6. Control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

C. Device Mounting

1. Devices shall be installed in accordance with manufacturers' recommendations and as shown.

2. Field Mounting: All field mounted instruments which are not self-supporting shall be mounted on 2 inch extra-strong 316 Stainless steel pipe stands.

3. Location and Access: All field mounted instrumentation shall be located near platforms, walkways, etc., to allow easy access for maintenance and adjustments.

4. Clearance at Aisles and Access Ways: Connections shall be made so that instruments or instrument piping do not obstruct aisles or access ways.

5. Local or Field Located Panels: All back-of-panel construction (conduit runs, tubing racks, braces, etc.) shall be installed to avoid interference with future full utilization of panel space and shall be properly supported and installed in a neat and orderly manner.

6. Control devices to be installed in piping shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration.

7. Any deviations shall be documented and submitted to the Engineer for approval prior to mounting.

D. Damaged insulation shall be replaced or repaired after devices are installed to match existing work.

E. Damaged galvanized surfaces shall be repaired by touching up with zinc paint.

F. Grooved Mechanical Joints

1. Grooves shall be prepared according to the coupling manufacturer's instructions.

2. Grooved fittings, couplings, and grooving tools shall be the products of the same manufacturer.

3. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer.

4. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded.

G. Sequences of Operation: Study the operation and sequence of local equipment controls, as a part of the conditions report, and note any deviations from the described sequences of operation on the contract drawings. Perform necessary adjustments to make the equipment operate in an optimum manner and fully document changes made.

3.3 Installation Of Equipment

A. Install equipment as specified, as shown, and as required in the manufacturer's instructions for a complete and fully operational control system.

B. Conduit, Connectors, and Fittings: All conduit, connectors, and fittings shall be in accordance with the requirements of Division 26.

C. Control Panels: Control panels shall be located as indicated on the drawings. Devices located in the control panels shall be as shown on the drawings or as needed to provide the indicated control sequences. Care shall be taken to prevent damage to the panels by area construction. Panels shall be covered for protection should painting or sand blasting be required in the area.

D. Instrument Shelters: Instrument shelters shall be installed in the location shown with the bottom 4.0 feet above the supporting surface using legs and secured rigidly to minimize vibrations from winds. Instrument shelters shall be oriented with door facing North. Instruments located in shelters shall be mounted in the 3-dimensional center of the open space of the shelter.

E. Electric Power Devices:

1. Potential and Current Transformers: Install potential and current transformers in enclosures unless otherwise shown. Current transformer leads shall be shorted when they are not connected to the measurement circuits.

2. Hour Meters: Meters shall be located in the control panel or as otherwise shown. Power to the meter shall be connected to the motor starter auxiliary contacts for pumps, blowers, and other motor driven devices. For devices without motor starters, the meter shall be connected in parallel with the load. Where the meter voltage differs from the metered devices voltage, transformer shall be provided as necessary.

3. Current Sensing Relays and Current Transducers for Motors: When used to sense meter/fan/pump status, current sensing relays shall be used for applications under 5 hp. Applications over 5 hp shall use a current transducer.

F. Output Devices: Output devices (transducers, relays, contactors, or other devices) which are not an integral part of the control panel, shall be mounted in an enclosure mounted adjacent to the control panel, unless otherwise shown. Where H-O-A and/or override switches on the drawings or required by the control sequence, the switches shall be installed so that the control system controls the function through the automatic position and other controls work through the hand position.

G. Enclosures: All enclosure penetrations shall be from the bottom of the enclosure and shall be sealed to preclude entry of water using a silicone rubber sealant.

H. Transformers:

1. Transformers for control voltages below 120 V ac shall be fed from the nearest power panel or motor control center, using circuits provided for the purpose.

2. Provide a disconnect switch on the primary side and a fuse on the secondary side.

3. Transformers shall be enclosed in a steel cabinet with conduit connections.

3.4 Wire, Cable And Connecting Hardware

A. All wiring shall be in accordance with the requirements of Division 26 and the following.

B. Metering and Sensor Wiring: Metering and sensor wiring shall be installed in accordance with the requirements of ANSI C12.1, NFPA 70, and Section 26 05 23 – Control Voltage Electrical Power Cables.

C. Power Line Surge Protection: Control panels shall be protected from power line surges. Protection shall meet the requirements of IEEE C62.41.1 and IEEE C62.41.2. Fuses shall not be used for surge protection.

D. Sensor and Control Wiring Surge Protection:

1. Digital and analog inputs shall be protected against surges induced on control and sensor wiring. Protect digital and analog outputs against surges induced on control and sensor wiring installed outdoors and as shown.

2. Fuses shall not be used for surge protection.

3. Test the inputs and outputs in both the normal and common mode using the following two waveforms:

E. The first waveform shall be 10 microseconds by 1000 microseconds with a peak voltage of 1500 volts and a peak current of 60 amperes.

F. The second waveform shall be 8 microseconds by 20 microseconds with a peak voltage of 1000 volts and a peak current of 500 amperes.

1. Submit certified test results for surge protection.

3.5 Software Installation

A. Load software required for an operational control system, including databases (for points specified and shown), operational parameters, and system, command, and application programs.

B. Adjust, tune, debug, and commission all software and parameters for controlled systems to assure proper operation in accordance with the sequences of operation and database tables.

3.6 HMI Screens

A. Allow for a minimum of 15 screens plus overlays for each pump, tank, and valve loop.

B. Allow for two sessions of two-day on-site meetings to develop screens with owner.

3.7 Integration Of Vendor Systems Into Plant SCADA

A. Integrate screens to monitor and control Influent Pump Station.

3.8 Control Drawings

A. Control drawings, reproducible, with corresponding CADD files, shall be provided for equipment furnished and for interfaces to equipment at each respective equipment location.

B. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system manually shall be prepared in typed form, reproducible, with corresponding word processor files and posted beside the diagrams.

C. Diagrams and instructions shall be submitted prior to posting.

D. The framed instructions shall be posted before acceptance testing of the system.

3.9 Field Testing And Adjusting Equipment

A. Provide personnel, equipment, instrumentation, and supplies necessary to perform site testing. The Engineer and Owner will witness the PVT, and written permission shall be obtained from the Engineer before proceeding with the testing.

B. Original copies of data produced, including results of each test procedure, during PVT shall be turned over to the Owner at the conclusion of each phase of testing prior to Owner approval of the test.

C. The test procedures shall cover actual equipment and functions specified for the project.

D. Testing, Adjusting and Commissioning

1. After successful completion of the factory test as specified, the Contractor will be authorized to proceed with the installation of the system equipment, hardware, and software.

2. Once the installation has been completed, test, adjust, and commission each control loop and system in accordance with NIST SP 250 and shall verify proper operation of each item in the sequences of operation, including hardware and software.

3. Calibrate field equipment, including control devices, adjust control parameters and logic (virtual) points including control loop setpoints, gain constants, constraints, and verify data communications before the system is placed online.

4. Test installed ground rods as specified in IEEE 142 and submit certification stating that the test was performed in accordance with IEEE 142.

5. Calibrate each instrumentation device connected to the control system control network by making a comparison between the reading at the device and the display at the workstation, using a standard at least twice as accurate as the device to be calibrated.

6. Check each control point within the control system control network by making a comparison between the control command at the central station and field-controlled device. Deliver trend logs/graphs of all points showing to the Engineer that stable control has been achieved.

7. Points on common systems shall be trended simultaneously.

8. One log shall be provided showing concurrent samples taken once a minute for a total of 4 hours. One log shall be provided showing concurrent samples taken once every 30 minutes, for a total of 24 hours.

9. Verify operation of systems in the specified failure modes upon Control system network failure or loss of power and verify that systems return to control system control automatically upon a resumption of control system network operation or return of power.

10. Deliver a report describing results of functional tests, diagnostics, calibrations, and commissioning procedures including written certification to the Owner that the installed complete system has been calibrated, tested, adjusted and commissioned and is ready to begin the PVT. The report shall also include a copy of the approved PVT procedure.

3.10 Performance Verification Test (PVT)

A. Submit test procedures for the PVT.

B. The test procedure shall describe all tests to be performed and other pertinent information such as specialized test equipment required and the length of the PVT.

C. The test procedures shall explain, in detail, step-by-step actions and the expected results, to demonstrate compliance with all the requirements of the drawings and this specification.

D. The test procedure shall be site specific and based on the inputs and outputs, required calculated points and the sequence of control.

E. Refer to the actions and expected results to demonstrate that the control system performs in accordance with the sequence of control.

F. Include a list of the equipment to be used during the testing plus manufacturer's name, model number, equipment function, the date of the latest calibration and the results of the latest calibration.

G. Demonstrate that the completed Control system complies with the contract requirements.

H. All physical and functional requirements of the project including communication requirements shall be demonstrated and shown.

I. Demonstrate that each system operates as required in the sequence of operation.

J. The PVT as specified shall not be started until after receipt of written permission by the Owner, based on the written report including certification of successful completion of testing, adjusting, and commissioning as specified, and upon successful completion of training as specified.

K. Upon successful completion of the PVT, furnish test reports and other documentation.

3.11 Endurance Test

A. Use the endurance test to demonstrate the overall system reliability of the completed system. The endurance test shall be conducted in phases.

B. The endurance test shall not be started until the Engineer notifies the Contractor in writing that the PVT is satisfactorily completed, training as specified has been completed, outstanding deficiencies have been satisfactorily corrected, and that the Contractor has permission to start the endurance test.

C. Provide an operator to man the system 8 hours per day during daytime operations, including weekends and holidays, during Phase I endurance testing, in addition to any Owner’s personnel that may be made available.

D. The Owner may terminate testing at any time when the system fails to perform as specified.

E. Upon termination of testing by the Owner or by the Contractor, commence an assessment period as described for Phase II.

F. Upon successful completion of the endurance test, deliver test reports and other documentation, as specified, to the Owner prior to acceptance of the system.

G. Phase I (Testing)

1. The test shall be conducted 24 hours per day, 7 days per week, for 30 consecutive calendar days, including holidays, and the system shall operate as specified.

2. Make no repairs during this phase of testing unless authorized by the Engineer in writing.

H. Phase II (Assessment)

1. After the conclusion of Phase I, identify failures, determine causes of failures, repair failures, and deliver a written report to the Engineer. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and shall recommend the point at which testing should be resumed.

2. After delivering the written report, convene a test review meeting at the job site to present the results and recommendations to the Engineer and Owner.

3. The meeting shall not be scheduled earlier than 5 business days after receipt of the report by the Engineer.

4. As a part of this test review meeting, demonstrate that failures have been corrected by performing appropriate portions of the performance verification test.

5. The Owner reserves the right to cancel the test review meeting if no failures or deficiencies occur during the Phase I testing. If the Owner chooses to do so, the Contractor will be notified in writing.

6. Based on the Contractor's report and the test review meeting, the Owner will determine if retesting is necessary and the restart point.

7. The Owner reserves the right to require that the Phase I test be totally or partially rerun. Do not commence any required retesting until after receipt of written notification by the Owner.

8. After the conclusion of any retesting which the Owner may require, the Phase II assessment shall be repeated as if Phase I had just been completed.

I. Exclusions: The Contractor will not be held responsible for failures resulting from the following:

1. Outage of the main power supply in excess of the capability of any backup power source, provided that the automatic initiation of all backup sources was accomplished, and that automatic shutdown and restart of the control system performed as specified.

2. Failure of an Owner-furnished communications link, provided that the PLC automatically and correctly operates in the stand-alone mode as specified,

and that the failure was not due to Contractor furnished equipment, installation, or software.

3. Failure of existing equipment, provided that the failure was not due to Contractor furnished equipment, installation, or software.

3.12 Manufacturers' Field Services

A. Obtain the services of a manufacturer's representative experienced in the installation, adjustment, and operation of the equipment specified.

B. The representative shall supervise the installing, adjusting, and testing of the equipment.

END OF SECTION

CONTROL NARRATIVE
LOWER POPLAR
WATER RECLAMATION FACILITY
INFLUENT PUMP STATION

Prepared For: Macon Water Authority

36181-21
August 2024

CONTENTS

I-O List

1.0 INTRODUCTION

This document is intended to describe the general operation and control of the equipment provided as part of the Influent Pump Station project. The control narrative is used in conjunction with the Process and Instrumentation Diagrams (P&IDs) to describe operation and control of the pump station.

1.1 Associated P&IDs

04-DI001, 04-DI002, 04-DI003, 04-DI801, 04-DI901, 04-DI902, & 04-DI903

2.0 PLANT CONTROL SYSTEM

This section describes the existing general plant control system architecture and the expansion to accommodate the new pump equipment and removal of obsolete pumping controls.

2.1 SCADA System Infrastructure

Macon Water Authority Lower Poplar currently utilizes a facility wide SCADA system. This system is linked to the MWA overall SCADA system via radio. The existing radio system at the Lower Poplar Influent Pump Station shall be relocated to one of the new RTU panels (RTU-1/RTU-2). A new RTU panel will be installed in each new E House and connected using a new fiber optic cable in underground raceway. Each RTU panel shall include an HMI screen on the front panel. One HMI panel (HMI-1) shall be provided for the canopy area. The HMI-1 panel shall be connected to each new RTU panel via fiber. The Existing control panel CP-200 at the Grit Structure shall be used for connection of new flow meters.

2.2 SCADA System Software

Any existing relevant pumping input/output (I/O), graphics and database parameters not reused shall be removed. New graphics, alarms, and data archiving added to the new HMI panels as indicated from the contract documents. Existing SCADA screens available to operators at all relevant workstations shall be updated to reflect the new pumping system.

HMI status indications and alarms indicated herein are minimum requirements. Reference the applicable P&ID drawings for each system for detailed HMI status indication and alarm requirements.

Alarms shall be annunciated at the local HMI on a pop-up message with red flashing border. The operator will need to go to a separate alarm graphic to acknowledge the alarm. The plant SCADA system will indicate alarms, acknowledging and reset will occur at the HMI. The separate alarm graphic at the local HMI will log all alarms and provide all pertinent data as to what the alarm was, the parameters of normal, and the parameters that were not in conformance.

2.3 Sampler

Existing sampler to remain and shall be connected to new RTU-1. The sampler shall be paced with an analog output. Pacing is currently calculated based on influent plant flow. The existing programming logic shall be moved to new RTU-1 plc. The influent plant flow rate shall be determined by the new flow meters (FE-9003 & FE-9004).

2.4 Screen Control Panels

Existing Screen Control Panels (CP0801 & CP-0802) shall be relocated from existing IPS electrical room to the Canopy. All existing I/O outlined in contract documents is to be reconnected to existing Screen Control Panels at new locations. The Screen Control Panels are local only and do not connect back to SCADA.

2.5 Wet Well and Pumps

The Wet Well is divided into two trains (Wet Well A & Wet Well B). During normal operation, the two trains operate as a singular wet well. Manually operated gates not connected to SCADA exist at the pump station to separate the two wet wells for Maintenance.

There are two large pumps (14 MGD) and one small pump (7 MGD) in each wet well.

Table 2.5.1 Pump Station

Equipment Tag	Description
WET WELL A	Pump Station Wetwell
WET WELL B	Pump Station Wetwell
P-1,2,4,5	(4) each 14 MGD Pumps
P-3,6	(2) each 7 MGD Pump
VFD-P-1,2,3,4,5,6	Pump Variable Frequency Drives

2.5.1 Pumps (P-1, 2, 3, 4, 5 & 6)

Pump Station VFDs are to be connected to the PCS via ethernet connection in addition to hard-wired signals specified in the contract documents. Pumps shall be protected by motor protection relay provided with the pumps. Protection shall include temperature and moisture detection. In the case of a fault, the pump shall shut down and an alarm will be sent to SCADA.

Pumps shall be designed for automatic and manual control. Manual operations for the small pumps are located on the VFDs in each E House. Automatic control shall be via SCADA and local HMI control panels. Pumping shall be fully controlled in automatic and remote manual modes via the SCADA system.

Pump Station VFDs are provided with a soft start bypass. During operation in bypass mode, the pumps will be controlled manually.

2.5.2 Seven MGD Pumps and Flow Meter (P-3 & P-6) (FE-9100 & FE-9200)

Each seven MGD pump shall have a flow meter on the discharge. The flow meter will be displayed on the SCADA screen. The seven MGD Pumps are designed to run at a minimum of 60%. If the flow meter on the discharge of the small pump is detected to be less than 60% of the small pump's capacity, then the pump will shut down and an alarm sent to SCADA. This will also initiate a local horn and strobe located at HMI-1.

2.5.3 Wet Well Level Switches and Transmitters

Each wet well will include a level transmitter to continuously report the wet well's water level to SCADA. The SCADA system will have a selection to choose a primary and secondary transmitter or average the two transmitters' readings.

Each wet well will include a low-level switch and high level switch. The low-level switch will report back to SCADA and shut down all 6 pumps. The high-level switch will report back to SCADA and an alarm displayed.

2.5.4 Pump Sequence of Operations (Hand/Off/Auto)

The VFD for each pump will have a Hand-Off-Auto on the front panel. When the pump is placed in "Local/Hand" at the VFD, it shall be possible to start/stop and control the speed of the pump at the VFD interface.

When the pump is placed in "Auto/Remote" at the VFD, it shall be possible to run in fully automatic mode or for the operator to start, stop, or adjust speed (if applicable) of the pump from the Operator Workstation or HMI Interface.

2.5.5 Pump Sequence of Operations (Fully Automatic)

When the pump is placed in "Auto/Remote" at the VFD and placed in Fully Automatic at the HMI or Operator workstation, then the pumps shall run the following sequence to maintain the wet well level at water level set point and within a one-foot band from the set point. The initial water level shall be 5 feet AFF and shall be adjustable by the operator.

One small pump shall run first to maintain the wet well level within the one foot band. If the water level continues to trend higher beyond the capacity of the small pump, then the second small pump shall turn on at 60% speed and the first pumps speed reduced to match. If the water continues to trend higher, the small pumps speed will ramp up accordingly. The two 7 MGD pump operations shall be designed to have equal run time.

If the level continues to trend high beyond the capacity of both small pumps, a large 14 MGD pump will turn on and the small pumps speed adjusted by SCADA. Similarly, additional 14 MGD pumps will turn on as the level continues to trend upward. The 14 MGD pump operations shall be designed to have equal run time.

When the low end of the wet well set point is reached, the last pump to turn on will turn off and the remaining pumps speeds adjusted by SCADA. If the water level continues to trend downward, an additional pump will turn off and the remaining pumps speeds adjusted.

All large pumps should run at matching speeds. The large pumps do not have flow meters on the discharge piping. The large pump rates are to be calculated by SCADA using the total flow output (FE-9003 & FE-9004) minus the small pump flows (FE-9100 & 9200) and diving by the total number of large pumps running.

All setpoints are to be displayed on SCADA and adjustable by Operators.

2.5.5 Control Valves (PV-1, 2, 3, 4, 5, 6, 7, 8, 9, 10 & 11)

Electrically operated control valves on the discharge pumping of the wet well shall be locally controlled only. Control Valves are not connected to SCADA. Valves in the discharge piping and force mains shall remain normally open.

2.6 Plant Influent Flow Meters (FE-9003, FE-9004)

The value of these two meters shall be combined and reported as the Plant Influent flow. Currently, the plant flow is measured at Parshall flumes in the Grit Area. The Parshall flume flow rate shall be monitored by SCADA only. The current calculation by SCADA will be updated to utilize the new Flow Meters readings.

I-O LIST

The I-O list shall be implemented into the respective DCS remote I-O panels

TAG ID	LOCATION	DEVICE	DESCRIPTION	I/O TAG	I/O TYPE	PLC CABINET	P&ID DWG #	WIRING DIA DWG #
AKB-0815	CANOPY	AIR KNIFE BLOWER	RUNNING STATUS	YI0815	DI	RTU-1	04-DI801	99-E852
AKB-0825	CANOPY	AIR KNIFE BLOWER	RUNNING STATUS	YI0825	DI	RTU-2	04-DI801	99-E853
SAMP-0801	SAMPLER MH	SAMPLER	PACING	FC0801	AO	RTU-1	04-DI801	99-E852
FIT-9100	PUMP STATION	FLOW ELEMENT	FLOW RATE	FI9100	AI	RTU-1	04-DI901	99-E852
GCD-9001	CANOPY	COMBUSTIBLE GAS DETECTOR	GAS LEVEL		AI	RTU-1	04-DI901	99-E852
LIT-9001	PUMP STATION	RADAR LEVEL SENSOR	LEVEL VALUE	LT9001	AI	RTU-1	04-DI901	99-E852
LSL-9003	WET WELL A	FLOAT SWITCH	LOW LEVEL STATE	LAL9003	DI	RTU-1	04-DI901	99-E852
LSH-9002	WET WELL A	FLOAT SWITCH	HIGH LEVEL STATE	LAH9002	DI	RTU-1	04-DI901	99-E852
MPR-A	ELECTRICAL BUILDING A	P-1 TEMPERATURE ELEMENT	TEMPERATURE VALUE	TAH9010	AI	RTU-1	04-DI901	99-E852
MPR-A	ELECTRICAL BUILDING A	P-1 MOISTURE ELEMENT	MOISTURE VALUE	MAH9010	AI	RTU-1	04-DI901	99-E852
MPR-A	ELECTRICAL BUILDING A	P-2 TEMPERATURE ELEMENT	TEMPERATURE VALUE	TAH9020	AI	RTU-1	04-DI901	99-E852
MPR-A	ELECTRICAL BUILDING A	P-2 MOISTURE ELEMENT	MOISTURE VALUE	MAH9020	AI	RTU-1	04-DI901	99-E852
MPR-A	ELECTRICAL BUILDING A	P-3 TEMPERATURE ELEMENT	TEMPERATURE VALUE	TAH9030	AI	RTU-1	04-DI901	99-E852
MPR-A	ELECTRICAL BUILDING A	P-3 MOISTURE ELEMENT	MOISTURE VALUE	MAH9030	AI	RTU-1	04-DI901	99-E852
VFD-P-1	ELECTRICAL BUILDING A	P-1 VFD HAND SWITCH	BYPASS STATUS	YI9010A	DI	RTU-1	04-DI901	99-E852
VFD-P-1	ELECTRICAL BUILDING A	P-1 VFD	RUN COMMAND	JC9010	DO	RTU-1	04-DI901	99-E852
VFD-P-1	ELECTRICAL BUILDING A	P-1 VFD	IN-AUTO STATUS	YI9010B	DI	RTU-1	04-DI901	99-E852
VFD-P-1	ELECTRICAL BUILDING A	P-1 VFD	RUNNING STATUS	YI9010C	DI	RTU-1	04-DI901	99-E852
VFD-P-1	ELECTRICAL BUILDING A	P-1 VFD	COMMON FAULT STATUS	YA9010	DI	RTU-1	04-DI901	99-E852
VFD-P-1	ELECTRICAL BUILDING A	P-1 VFD	COMMAND SPEED	SC9010	AO	RTU-1	04-DI901	99-E852
VFD-P-1	ELECTRICAL BUILDING A	P-1 VFD	INDICATED SPEED	SI9010	AI	RTU-1	04-DI901	99-E852
VFD-P-2	ELECTRICAL BUILDING A	P-2 VFD HAND SWITCH	BYPASS STATUS	YI9020A	DI	RTU-1	04-DI901	99-E852
VFD-P-2	ELECTRICAL BUILDING A	P-2 VFD	RUN COMMAND	JC9020	DO	RTU-1	04-DI901	99-E852
VFD-P-2	ELECTRICAL BUILDING A	P-2 VFD	IN-AUTO STATUS	YI9020B	DI	RTU-1	04-DI901	99-E852
VFD-P-2	ELECTRICAL BUILDING A	P-2 VFD	RUNNING STATUS	YI9020C	DI	RTU-1	04-DI901	99-E852
VFD-P-2	ELECTRICAL BUILDING A	P-2 VFD	COMMON FAULT STATUS	YA9020	DI	RTU-1	04-DI901	99-E852
VFD-P-2	ELECTRICAL BUILDING A	P-2 VFD	COMMAND SPEED	SC9020	AO	RTU-1	04-DI901	99-E852

VFD-P-2	ELECTRICAL BUILDING A	P-2 VFD	INDICATED SPEED	SI9020	AI	RTU-1	04-DI901	99-E852
VFD-P-3	ELECTRICAL BUILDING A	P-3 VFD HAND SWITCH	BYPASS STATUS	YI9030A	DI	RTU-1	04-DI901	99-E852
VFD-P-3	ELECTRICAL BUILDING A	P-3 VFD	RUN COMMAND	JC9030	DO	RTU-1	04-DI901	99-E852
VFD-P-3	ELECTRICAL BUILDING A	P-3 VFD	IN-AUTO STATUS	YI9030B	DI	RTU-1	04-DI901	99-E852
VFD-P-3	ELECTRICAL BUILDING A	P-3 VFD	RUNNING STATUS	YI9030C	DI	RTU-1	04-DI901	99-E852
VFD-P-3	ELECTRICAL BUILDING A	P-3 VFD	COMMON FAULT STATUS	YA9030	DI	RTU-1	04-DI901	99-E852
VFD-P-3	ELECTRICAL BUILDING A	P-3 VFD	COMMAND SPEED	SC9030	AO	RTU-1	04-DI901	99-E852
VFD-P-3	ELECTRICAL BUILDING A	P-3 VFD	INDICATED SPEED	SI9030	AI	RTU-1	04-DI901	99-E852
FIT-9200	PUMP STATION	FLOW ELEMENT	FLOW RATE	FI9200	AI	RTU-2	04-DI902	99-E853
LIT-9004	PUMP STATION	RADAR LEVEL SENSOR	LEVEL VALUE	LT9004	AI	RTU-2	04-DI902	99-E853
LSL-9006	WET WELL B	FLOAT SWITCH	LOW LEVEL STATE	LAL9005	DI	RTU-2	04-DI902	99-E853
LSH-9005	WET WELL B	FLOAT SWITCH	HIGH LEVEL STATE	LAH9006	DI	RTU-2	04-DI902	99-E853
MPR-B	ELECTRICAL BUILDING B	P-4 TEMPERATURE ELEMENT	TEMPERATURE VALUE	TAH9040	AI	RTU-2	04-DI902	99-E853
MPR-B	ELECTRICAL BUILDING B	P-4 MOISTURE ELEMENT	MOISTURE VALUE	MAH9040	AI	RTU-2	04-DI902	99-E853
MPR-B	ELECTRICAL BUILDING B	P-5 TEMPERATURE ELEMENT	TEMPERATURE VALUE	TAH9050	AI	RTU-2	04-DI902	99-E853
MPR-B	ELECTRICAL BUILDING B	P-5 MOISTURE ELEMENT	MOISTURE VALUE	MAH9050	AI	RTU-2	04-DI902	99-E853
MPR-B	ELECTRICAL BUILDING B	P-6 TEMPERATURE ELEMENT	TEMPERATURE VALUE	TAH9060	AI	RTU-2	04-DI902	99-E853
MPR-B	ELECTRICAL BUILDING B	P-6 MOISTURE ELEMENT	MOISTURE VALUE	MAH9060	AI	RTU-2	04-DI902	99-E853
VFD-P-4	ELECTRICAL BUILDING B	P-4 VFD HAND SWITCH	BYPASS STATUS	YI9040A	DI	RTU-2	04-DI902	99-E853
VFD-P-4	ELECTRICAL BUILDING B	P-4 VFD	RUN COMMAND	JC9040	DO	RTU-2	04-DI902	99-E853
VFD-P-4	ELECTRICAL BUILDING B	P-4 VFD	IN-AUTO STATUS	YI9040B	DI	RTU-2	04-DI902	99-E853
VFD-P-4	ELECTRICAL BUILDING B	P-4 VFD	RUNNING STATUS	YI9040C	DI	RTU-2	04-DI902	99-E853
VFD-P-4	ELECTRICAL BUILDING B	P-4 VFD	COMMON FAULT STATUS	YA9040	DI	RTU-2	04-DI902	99-E853
VFD-P-4	ELECTRICAL BUILDING B	P-4 VFD	COMMAND SPEED	SC9040	AO	RTU-2	04-DI902	99-E853
VFD-P-4	ELECTRICAL BUILDING B	P-4 VFD	INDICATED SPEED	SI9040	AI	RTU-2	04-DI902	99-E853
VFD-P-5	ELECTRICAL BUILDING B	P-5 VFD HAND SWITCH	BYPASS STATUS	YI9050A	DI	RTU-2	04-DI902	99-E853
VFD-P-5	ELECTRICAL BUILDING B	P-5 VFD	RUN COMMAND	JC9050	DO	RTU-2	04-DI902	99-E853
VFD-P-5	ELECTRICAL BUILDING B	P-5 VFD	IN-AUTO STATUS	YI9050B	DI	RTU-2	04-DI902	99-E853
VFD-P-5	ELECTRICAL BUILDING B	P-5 VFD	RUNNING STATUS	YI9050C	DI	RTU-2	04-DI902	99-E853

VFD-P-5	ELECTRICAL BUILDING B	P-5 VFD	COMMON FAULT STATUS	YA9050	DI	RTU-2	04-DI902	99-E853
VFD-P-5	ELECTRICAL BUILDING B	P-5 VFD	COMMAND SPEED	SC9050	AO	RTU-2	04-DI902	99-E853
VFD-P-5	ELECTRICAL BUILDING B	P-5 VFD	INDICATED SPEED	SI9050	AI	RTU-2	04-DI902	99-E853
VFD-P-6	ELECTRICAL BUILDING B	P-6 VFD HAND SWITCH	BYPASS STATUS	YI9060A	DI	RTU-2	04-DI902	99-E853
VFD-P-6	ELECTRICAL BUILDING B	P-6 VFD	RUN COMMAND	JC9060	DO	RTU-2	04-DI902	99-E853
VFD-P-6	ELECTRICAL BUILDING B	P-6 VFD	IN-AUTO STATUS	YI9060B	DI	RTU-2	04-DI902	99-E853
VFD-P-6	ELECTRICAL BUILDING B	P-6 VFD	RUNNING STATUS	YI9060C	DI	RTU-2	04-DI902	99-E853
VFD-P-6	ELECTRICAL BUILDING B	P-6 VFD	COMMON FAULT STATUS	YA9060	DI	RTU-2	04-DI902	99-E853
VFD-P-6	ELECTRICAL BUILDING B	P-6 VFD	COMMAND SPEED	SC9060	AO	RTU-2	04-DI902	99-E853
VFD-P-6	ELECTRICAL BUILDING B	P-6 VFD	INDICATED SPEED	SI9060	AI	RTU-2	04-DI902	99-E853
FIT-9003	INFLUENT FORCE MAIN MV	FLOW ELEMENT	FLOW RATE	FI9002	AI	RTU-X (CP-200)	04-DI903	99-E854
FIT-9004	INFLUENT FORCE MAIN MV	FLOW ELEMENT	FLOW RATE	FI9003	AI	RTU-X (CP-200)	04-DI903	99-E854

Instrument Schedule - Summary

Loop ID	Tag	Function	Accessory 1 Tag	Accessory 2 Tag	Loop Title	Instrument Name	Component Code	P&ID Dwg. No.	Design Detail
	SAMP-0801		FE-0801		INFLUENT SCREENS	Flow Element & Transmitter, Electromagnetic		04-DI801	
	LIT-9001		LE-9001		INFLUENT PUMP STATION WET WELL A	Level Transmitter, Submersible		04-DI901	
	LSH-9002				INFLUENT PUMP STATION WET WELL A	Level Switch, Tilt Bulb		04-DI901	
	LSL-9003				INFLUENT PUMP STATION WET WELL A	Level Switch, Tilt Bulb		04-DI901	
	FIT-9100		FE-9100		INFLUENT PUMP STATION WET WELL A	Flow Element & Transmitter, Electromagnetic		04-DI901	
	LIT-9004		LE-9004		INFLUENT PUMP STATION WET WELL B	Level Transmitter, Submersible		04-DI902	
	LSH-9005				INFLUENT PUMP STATION WET WELL B	Level Switch, Tilt Bulb		04-DI902	
	LSL-9006				INFLUENT PUMP STATION WET WELL B	Level Switch, Tilt Bulb		04-DI902	
	FIT-9200		FE-9200		INFLUENT PUMP STATION WET WELL B	Flow Element & Transmitter, Electromagnetic		04-DI902	
	FIT-9003		FE-9003		INFLUENT PUMP STATION FORCE MAIN	Flow Element & Transmitter, Electromagnetic		04-DI903	
	FIT-9004		FE-9004		INFLUENT PUMP STATION FORCE MAIN	Flow Element & Transmitter, Electromagnetic		04-DI903	

Part 1 General

1.1 Scope

A. This Section covers the furnishing of flow instruments and accessories required for the Plant Control System as indicated on the Drawings.

B. When multiple instruments of a particular type are specified, and each requires different features, the required features are described on the Drawings or the Instrument Device Schedule.

1.2 Related Sections

A. Section 40 60 00 – Process Controls.

1.3 Design Criteria

A. Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by Contractor.

B. Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

C. The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the Drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the Drawings or in the Instrument Device Schedule.

D. Each instrument shall be factory wet flow calibrated to the full scale flow range of the sensors or calibration ranges indicated on the Drawings or in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Testing (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration and configuration data shall be stored digitally in each device, including the instrument tag designation indicated on the Drawings or Instrument Device Schedule.

1.4 Submittals

A. Submittals shall be made in accordance with Section 01 33 00 and Section 40 60 00.

Part 2 Products

2.1 General

A. The following paragraphs provide minimum device requirements. The Drawings shall be used to determine any additional instrument options, requirements, or service conditions.

1. Interconnecting Cable. For instruments where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter. Length of cable shall be a minimum of 15 feet or as indicated on the Drawings. Splices shall not be allowed in the installed cable.

2. Programming Device. For instruments that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Owner facility. The programming device shall include appropriate operation manuals and shall be included in the training requirements. For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.

3. Configuration Software/Serial Interface. Devices indicated as requiring a serial interface shall be provided with all accessories required to properly communicate over the serial link. As a minimum, an appropriate cable shall be provided to allow the transmitter serial interface to be connected to a personal computer. One licensed copy of the diagnostic/interface software shall be provided for each Owner facility. Software shall be capable of running under the Windows XP operating system. If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device shall not be furnished.

B. Liquid flow indication shall be provided in gpm.

C. Pressure taps shall incorporate appropriate snubbers.

D. Unless indicated otherwise, the flow transmitter shall produce a signal that is proportional to the volumetric flow rate, compensated for fluid temperature, and shall have an accuracy of plus or minus 1 percent of the actual flow.

E. Flow transmitter shall be located within 15 feet of the flow element. The flow transmitter shall include a digital readout of the volumetric flow rate to 3 significant figures.

F. The transmitter shall provide a 4-20 mA dc output signal to the programmable logic controller, proportional to the measured parameter.

2.2 Electromagnetic Flowmeters, Signal Converters, and Accessories

A. Magnetic Flowmeter. The magnetic flowmeter shall be a completely obstructionless, in-line flowmeter with no constrictions in the flow of fluid through the meter. The meter shall consist of a metallic tube with flanged ends and with grounding rings or grounding electrodes as required by the application. Flange diameter and bolt drilling pattern shall comply with ANSI/ASME B16.5 for line sizes from one-half inch to 24 inches or AWWA C207 for line sizes larger than 24 inches. Flange class ratings and meter maximum pressure ratings shall be compatible with the adjoining piping.

1. The meter shall be capable of standing empty for extended periods of time without damage to any components.

2. The meter housing shall be submersible. The meter housing shall withstand continuous submergence in 30 feet of water.

B. Electrode and liner materials shall be fully compatible with the process fluid as approved by the Engineer and shall comply with the requirements specified in the instrument device schedules.

C. Each meter shall be factory wet flow calibrated to the sensor's full flow capacity, at a facility, which is traceable to NIST or other standard acceptable to Engineer, and a copy of the calibration, report shall be submitted as part of the operation and maintenance manual submittal.

D. Magnetic Flowmeter Signal Converters. Separately mounted, microprocessor-based signal converters shall be provided for the magnetic flowmeters. The signal converters shall include output damping, self-testing, built-in calibration capability, and an "empty pipe zero" contact input. Self-testing diagnostics shall include ability to detect drift from install. The overall accuracy of the magnetic flowmeter transmitter and signal converter shall be ±0.5 percent of actual flow rate for full-scale settings of 3 to 30 fps. The meter manufacturer shall furnish the signal cable between the converter and the magnetic flowmeter. Signal cable shall be continuous and not spliced between the meter and the signal converter. The signal converter, whether indoors or outdoors, shall be housed in a corrosion-resistant, weatherproof NEMA Type 4X enclosure with ¼ turn 3pt latch and shall be suitable for operation over an ambient temperature range of -30 to +140°F, and relative humidity of 10 to 100 percent. The converter shall have an analog output of 4-20 mA dc, with superimposed digital HART protocol. Transmitters tagged on the Drawings or specified to be of the indicating type shall contain a local indicator with a minimum four-digit LCD type display, scaled to read in engineering units of flow.

1. Magnetic flowmeter systems shall provide zero flow stability by means of automatic zero adjustment of a DC excited metering circuit. Converters shall be capable of bi-directional flow measurement and shall be capable of detecting and signaling reverse flow. Signal converters shall be of the same brand as the magnetic flowmeters.

2. The signal converter shall have a non-reset seven-digit totalizer on the face of the enclosure.

3. The signal converter shall be diagnosed and recalibrated with the use of a hand- held communicator/calibrator device. One device shall be furnished for all converters provided by a single manufacturer.

E. Manufacturers and Models

1. Rosemount 8705

2. Endress & Hauser, Inc. Promag W400

3. Toshiba LF654

Part 3 Execution

3.1 Equipment Installation Requirements

A. Installation: Install flow meter system components and appurtenances in accordance with the manufacturer's instructions and provide necessary interconnections, services, and adjustments required for a complete and operable system. Adjust or replace devices not conforming to the required accuracies. Replace factory sealed devices, rather than adjusting.

1. Install instrumentation and communication equipment and cable grounding as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.

2. Install wiring in exposed areas, including low voltage wiring, in PVC conduit below ground and stainless-steel conduit above ground.

B. Isolation, Penetrations and Clearance from Equipment: Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Installation shall provide clearance for control-system maintenance. Control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

C. Device Mounting: Devices shall be installed in accordance with manufacturers' recommendations and as shown. Devices to be installed in piping shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Any deviations shall be documented and submitted to the Engineer for approval prior to mounting. Damaged insulation shall be replaced or repaired after devices are installed to match existing work. Damaged galvanized surfaces shall be repaired by touching up with zinc paint.

3.2 Installation of Equipment

A. Install equipment as specified, as shown and as required in the manufacturer's instructions for a complete and fully operational control system.

B. Flow Measuring Devices: Fluid flow instruments shall be installed in accordance with manufacturer's recommendations, unless otherwise indicated in the specification.

C. Magnetic Flowmeter: Meter shall be installed so that the flow tube remains full of the process fluid under all operating conditions.

3.3 Wire, Cable and Connecting Hardware

A. Metering and Sensor Wiring: Metering and sensor wiring shall be installed in accordance with the requirements of ANSI C12.1, NFPA 70, Division 26, and Section 40 60 00.

B. Sensor and Control Wiring Surge Protection: Digital and analog inputs shall be protected against surges induced on control and sensor wiring. Protect digital and analog outputs against surges induced on control and sensor wiring installed outdoors and as shown. Fuses shall not be used for surge protection. Test the inputs and outputs in both the normal and common mode using the following two waveforms: The first waveform shall be 10 microseconds by 1000 microseconds with a peak voltage of 1500 volts and a peak current of 60 amperes. The second waveform shall be 8 microseconds by 20 microseconds with a peak voltage of 1000 volts and a peak current of 500 amperes. Submit certified test results for surge protection.

3.4 Field Services

A. Manufacturer's field services shall be provided for installation, field calibration, startup, and training.

B. Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. The System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

END OF SECTION

Part 1 General

1.1 Section Includes

A. Wet-pit submersible pump(s) complete with all appurtenances, accessories, and spare parts as required to produce a complete and workable installation and as specified herein.

B. All submersible pumps for this project shall be the product of one manufacturer.

1.2 Related Work Specified Elsewhere

A. Section 26 29 23 Variable -Frequency Motor Controllers

1.3 Submittals

A. Submit in accordance with Section 01 33 00.

B. Data to be submitted:

1. Pump curves for each size unit showing Total Dynamic Head, Pump Efficiency, Brake Horsepower, Power Input to Electric Drive Motor of Pumping Unit for the various conditions under which the units are to operate along with descriptive data and specifications describing in detail the construction of the complete units.

2. The manufacturer shall have a minimum of five installations of the exact combination of pump and motor model proposed to be furnished for this project. Installations must be in operation for a minimum of five years and shall list the pump model, motor model and horsepower, date of installation, duty point, and contact information including telephone number. A list of these installations shall be furnished to the Engineer with submittals.

3. Dimensional Data: Shop drawings, showing all weights and dimensions necessary for the installation of foundations, anchor bolts, piping and valve connections.

C. Submit operations and maintenance instructions in accordance with Section 01 78 23.

D. Complete operating and maintenance instructions shall be furnished for all equipment included under these specifications.

1. The maintenance instructions shall include troubleshooting data and full preventative maintenance schedules and complete spare parts lists with ordering information.

2. The manuals shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions, etc., that are required to instruct operation and maintenance personnel who are unfamiliar with such equipment.

E. Manufacturer's Installation and Startup Report: Submit in accordance with Section 01 75 16.

1.4 Warranty

A. The pumps and motors shall be covered by a five (5) year warranty that shall comprise the following terms: The initial year from start-up of the equipment shall be covered 100% for parts and labor. The following years 2 through 5 shall be covered 100% for parts. This warranty shall not be limited by hours of running time or operation from variable speed drives.

1.5 Spare Parts

A. The manufacturer shall furnish one set of the following spare parts:

1. O-Ring Set

2. Wear rings, of each size/type utilized

B. A written description of each spare part and the storage recommendation shall be provided as directed by the Engineer.

Part 2 Products

2.1 Manufacturers

Xylem Water Solutions USA inc.- Flygt NP 3531

2.2 Pump Performance:

A. Each pump shall be capable of the following performance:

Pump ID	P- 1, 2, 4, 5	P- 3 , 6
Service	Raw Wastewater	Raw Wastewater
Location	Influent Pump Station	Influent Pump Station
Installation	Wet Pit	Wet Pit
Duty Point Flow, (gpm)	9722	4861
Duty Point TDH, feet	56	56
Minimum Hydraulic Efficiency at Duty Point, %	84	80
Maximum NPSH-R at Duty Point, feet	10.1	12
Maximum Nominal Motor Power (HP)	215	100
Max. Motor Speed (nominal rpm)	600	900
Minimum Shut-off Pressure, feet	88	88
2ndry Point Flow (gpm)	13000	6800
2ndry Point TDH (ft)	43	42
Minimum Hydraulic Efficiency at Secondary Rating Point, %	81	70

2.3 Pump Construction

A. General

1. The sewage pumping units shall be vertical, non-clogging, centrifugal sewage pumps with bottom inlet and side discharge. The pumps shall be direct driven by integral squirrel cage, electric induction motors. Each pump shall include, as applicable, quick removal system, anchor bolts and all accessories specified herein.

2. The hydraulic of the pump shall be capable of handling raw domestic wastewater and storm water with fibrous materials like wet wipes.

3. The pump shall be capable to operate without any limitation between 50% and 125% of the Best efficiency point (B.E.P) of the performance curve.

4. The required shaft power (P2) in the guaranteed duty point shall be less than 184 HP for the Large Pumps and 89 HP for the small pumps . The maximum

motor speed shall be : 600 rpm for the large pumps and 900 rpm for the small pumps. A performance chart shall be provided showing curves for torque, current, power factor, input/output HP and efficiency. This chart shall also include data on starting and no-load characteristics

B. Volute

1. The volute shall be constructed of ASTM A48 minimum Class 30B or higher cast iron (GG20) capable of prolonged resistance to raw sewage.

2. Suction and discharge flanges shall be 125# and meet ANSI standard B16.1.

3. All nuts, bolts, washers, and other fastening devices supplied with the pumps shall be stainless steel.

4. All mating surfaces requiring a watertight seal shall be machined and fitted with O-rings. Paper gaskets are not acceptable.

C. Impeller

1. Pump impellers shall be of the solids handling non-clog type. The impeller vane shall be smooth, finished throughout, and shall be free from sharp edges. The impeller blades shall be self-cleaning upon each rotation as they pass across a sharp relief groove in the Insert ring and shall keep the impeller blades clear of debris. The clearance between the insert ring and the impeller leading edges shall be adjustable.

2. The impeller shall be made of high chromium cast iron with at least 24% chrome.

3. The impeller shall be mounted on the motor shaft. Couplings or gear boxes shall not be accepted. Impellers shall be key driven and securely held to the shaft by a streamlined impeller washer and bolt assembly specifically designed to reduce friction in the suction eye of the impeller. The arrangement shall be such that the impeller cannot unscrew or be loosened by torque from either forward or reverse rotation. Designs based on threaded connection between pump shaft and impeller will not be considered.

4. The impeller shall be capable of passing a 3-inch solid non-deformable sphere.

5. The impeller shall be dynamically balanced to provide smooth, vibration-free operation.

D. Wear Rings (Semi-Open Impellers)

1. An ASTM Class 30B or higher cast iron wear plate shall be factory mounted to the volute in a fixed position with metal to metal contact on machined surfaces to ensure optimal clearance. Adjustments shall be easily accomplished by removing securing screws and rotating the plate.

2.4 Motors

A. The pump motor voltage shall be 480 V, 3ph, 60 Hz. The pump motor shall be induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber. It shall be permanently submersible in accordance with standard IEC 60034 and protection class IP 68.

B. The motor shall be provided with an integral motor cooling system. A stainless steel cooling jacket shall encircle the stator housing, providing for dissipation of motor heat regardless of the type of pump installation. An impeller, integral to the cooling system and driven by the pump shaft, shall provide the necessary circulation of the cooling liquid through the jacket. The cooling liquid shall pass about the stator housing in the closed loop system in turbulent flow providing for superior heat transfer. The cooling system shall have one fill port and one drain port integral to the cooling jacket.

C. The pump shall be capable of operating in a continuous condition in a liquid with a temperature up to 104°F even when the motor is not submerged.

D. The motor shall be capable of no less than 15 evenly spaced starts per hour and be able to operate throughout the entire pump performance curve from shut-off through run-out.

E. The stator shall be insulated according moisture resistant Class H rated for 356°F. The stator windings shall be insulated with monomer-free polyester resin resulting in a winding fill rate of at least 96%. The design shall be inverter duty rated in accordance with NEMA MG1, Part 31

F. The junction chamber containing the terminal board shall be hermetically sealed from the motor by an elastomeric compression seal. Connection between the cable conductors and stator leads shall be made with threaded compression type binding posts permanently affixed to a terminal board.

G. The motor shall be protected by following sensors:

1. 3 bi-metal Thermal switches for thermal control of the stator
2. 3 PT 100 thermal sensor (RTD) to monitor the stator temperature of one Winding
3. 1 PT 100 thermal sensor (RTD) to monitor the temperature of the main bearing
4. 1 PT 100 thermal sensor (RTD) to monitor the temperature of the top bearing

5. 1 Vibration sensor to monitor vibration on 3 axes from 10 – 600 Hz.
    a) 1 float switch in leakage chamber to monitor leakage in the leakage chamber.
    b) 1 float switch in the terminal connection housing to monitor any leakage thru the cables and the cable entries.

H. The pump shall be supplied with a pump electronic module (PEM) mounted inside the motor. Mounting outside the motor is not allowed so that motor information stays with the motor. The PEM shall collect, store and digitize all measurements from all sensors and shall communicate the data in a digital format via 2 control leads integral to the pump power cable to a base unit mounted in a pump control cabinet to the central control unit. The signals from the sensors shall be digital and transferred by just 2 leads within the motor cable. For explosion proof applications a second shielded cable will connect the thermal sensors to a thermal relay (Mini CAS or Safe FSP). An additional pilot cable shall not be allowed. The PEM shall have information about the pump as well as features for startup and service support, such as:
1. Pump serial number and other data plate information.
2. Specific configuration of monitoring functions for the actual pump such as alarm limits, delays, reset types, etc.
3. Counters by which the system can generate service reminders in accordance with the service policy specified in the pump manual.
4. Operating data and alarm history to analyze the condition of the pump and enable troubleshooting and reporting.
5. Accumulated running time and number of starts.
6. Pump duty rate (percentage of operation).

I. The pump shall be Explosion approved according to fm class 1, division 1 "C" and "D".

J. The cable entry shall consist of dual cylindrical elastomer sleeves, flanked by washers, all having a close tolerance fit against the cable and the cable entry. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable.

2.5 Shafts

A. The pump shaft shall rotate on at least three grease-lubricated bearings. The upper bearing, provided for radial forces, shall be a single roller bearing. The lower bearings shall consist of at least one roller bearing for radial forces and one or two angular contact ball bearings for axial thrust. The minimum L10 bearing life shall be 100,000 hours at any point along the usable portion of the pump curve at maximum product speed. The lower bearing housing shall include an independent thermal sensor to monitor the bearing temperature. If a high temperature occurs, the sensor shall activate an alarm and shut the pump down. The bearings shall be insulated for VFD operation.

B. The shaft seal shall be a positively driven dual, tandem mechanical shaft seal system consisting of two seals, each having an independent spring system. The seal shall be in a separate lubricant chamber and be lubricated and cooled by environmental friendly medical white oil. The lubricant chamber shall be designed to prevent over-filling and shall provide capacity for lubricant expansion. It shall have one drain and one inspection plug that are accessible from the exterior of the motor unit. The seals shall require neither maintenance nor adjustment and shall be capable of operating in either clockwise or counter clockwise direction of rotation without damage or loss of seal function. The rotating inner seal ring shall have small back-swept grooves laser inscribed upon its face to act as a micro pump as it rotates, returning any fluid that should enter the dry motor chamber back into the lubricant chamber. Any leakage passing the sealing shall not pass the bearings. Before it reaches the bearings the liquid shall create an alarm via the floating leakage sensor.

2.6 Power and Control Cables

A. The motor shall be equipped with a screened cable suitable for submersible pump applications. The power cable shall be sized according to NEC and ICEA standards. The outer jacket of the cable shall be oil resistant chlorinated polyethylene rubber. The cable shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet. Each screened cable shall include 2 shielded communication wires.

B. Power and control cables shall be furnished in lengths to run un-spliced from the pump to a junction box or pump control panel as shown on the Contract Drawings and as specified herein. Cables shall terminate with conductor sleeves that bundle the entire group of strands of each phase to improve termination at the pump control panel. The sleeves shall be provided to confirm that all strands of each conductor are terminated properly.

C. Cables shall be of the "NSSHOU" type and shall be approved by the MSHA for use in hazardous locations and shall conform to industry standards for loads, resistance under submersion against sewage, and be of stranded construction. The cables shall enter the pump through a heavy duty entry assembly which shall be provided with an external clamp assembly to protect against tension once secured providing a strain relief function as part of standard construction.

D. The cable entry design shall be of the type recommended in the Factory Mutual Research Corporation specifications for Explosion Proof Certification.

E. The cable entry system shall terminate in line-up terminals constructed to allow exchange of the power cable through the use of only a standard screwdriver.

2.7 Monitoring and Status (FLYGT MAS 801)

A. The pump manufacturer shall supply a control system designed to monitor temperature and moisture in the pumps. A total of 2 monitoring units shall be supplied. Each unit shall monitor 3 pumps.

B. Each pump shall be connected by 2 control leads to the base unit (BU) and 2 control leads to the Mini-CAS or Safe FSP Relays. The control leads shall be part of the Motor cable. An additional Pilot cable shall not be allowed.

C. The Base Unit (BU) shall be able to stop the pump if required via an interlocking relay and it shall provide connections for optional measuring modules such as a power meter and other I/O modules.

D. The Mini-CAS or Safe FSP relay shall be able to stop the pump if required via an interlocking relay and the same interlocking relay will provide thermal status to the BU relay via Digital input (1 for each pump).

E. The Central Unit (CU) shall have a functionality based on embedded web pages that can be used through a PC or operator panel that allows:

1. A graphical user interface for configuration and analysis via computer and HMI
2. Pump status overview
3. Alarm management
4. Analysis through trend graphs and histograms.
5. External communication with any SCADA via Modbus RTU or Modbus TCP

F. The CU shall contain the same pump data and logged data stored in each pump electronic module for quick access and redundancy.

G. The system shall support the service and maintenance policy that applies to the pump by generating service reminders and graphically providing users with an overview of service status that facilitates planning of upcoming service

H. The Cabinet shall be equipped with HMI Touch panel for access and interaction with the Monitoring and Control system. The panel should be at least 15 inches in size and able to show color.

I. When a pump related alarm is generated, the system shall support the user in the form of:

1. Measurement data linked to the specific alarm item for analysis.
2. Text information about possible root cause errors.
3. Remedial actions.

2.8 Variable frequency Drive (VFD)

A. The VFDs shall be provided in compliance with specification section 26 29 23.

2.9 Removal System

A. The removal system shall consist of a discharge base elbow or straight-through fitting, as shown in the Contract Documents, that mounts in the bottom of the basin, a replaceable pump coupling, guide pipes and supports and hardware as required for a complete and operational system. Connections to piping shall be standard ANSI flanges.

B. Discharge Base Elbow: The ASTM A48 Class 30B or higher cast iron discharge base elbow or through fitting shall be provided to support the full weight of the submersible pump in the installation and provide a leak proof connection by the combined weight of the cantilevered pump and motor. The discharge base fitting shall be provided with guide pipe retention lugs.

C. Pump Coupling: The pump coupling shall be close grained gray cast iron construction. The coupling shall be located between the pump discharge flange and the vertical face of the discharge base. The purpose of the coupling shall be to allow use of a standard ANSI drilled pump-casing flange on the pump. The coupling acts as the intermediate part between the pump and the discharge base. The coupling vertical face shall be designed to seal against the vertical face of the discharge base.

D. Guide Rails: AISI 304 stainless steel guide rails supported by upper and intermediate brackets of AISI 316 stainless steel shall guide each submersible pump. The guide rails shall consist of standard dimension schedule 40 piping with a minimum diameter of 3 inches. The guide rails shall be supported by a AISI 316 upper guide rail bracket that will be mounted in the opening of the access cover to support and guide the pump/motor into and out of the basin/wet well. Intermediate guide rail brackets will be provided.

E. Lifting Device: Each pump shall be supplied with a lifting chain of AISI 304 Stainless Steel. The manufacturer shall provide information on recommended testing parameters that shall keep the lifting system capable of service for the life of the station. Recommendations shall be in written form and shall be discussed during startup training for the installation.

2.10 Shop Painting

A. Primer and Finish Paint - Shop apply to all exterior ferrous surfaces of the pump and motor. Shop apply to exterior and interior surfaces of elbow.

B. Solids by volume: 97%

C. Type: Solvent-free ceramic coating, impregnated with aluminum oxides

D. Total Dry Film Thickness: 400 microns (15 mils) minimum

E. Minimum Adhesion: 14 Newtons per square millimeter (2,030 psi) per ISO 4624.

F. Minimum Hardness: 110 on Buchholz Indentation scale

G. Resistance: Level 1.

H. Surface Preparation-Prepare all surfaces to receive coating system.

1. Method: Blasting per ISO 12944-4

2. Standard Cleanliness Grade: 2.5

3. Minimum Peak to Valley Height: 70 microns (2.75 mils)

Part 3 Execution

3.15 Field Quality Control

A. Field Testing:

1. After the installation of the pumps, controls and all appurtenances, and when construction of other units will permit, each complete pumping unit will be subject to field tests as specified herein under actual operating conditions.

2. The field tests shall be made by the Contractor under the direct supervision of a qualified factory trained engineer, and in the presence of, and as directed by the Engineer. The Contractor shall provide, calibrate and install all temporary gauges and meters, shall make necessary tapped holes in the pipes, and install all temporary piping and wiring required for the field tests.

3. The field tests shall determine the head, discharge flow and overall efficiency characteristics of each pumping unit and in addition, shall demonstrate that under all conditions of operation each unit:

a. Has not been damaged by transportation or installation.

b. Has been properly installed.

c. Has no mechanical defect.

d. Is in proper alignment.

e. Has been properly connected.

f. Is free of overheating of any parts.

g. Is free of all-objectionable vibration and noise.

h. Is free of overloading of any parts.

END OF SECTION