Four Rivers Sanitation Authority
Rockford, Illinois

Bidding Requirements and Contract Forms for
Primary Filtration Project Phase I

Capital Project No. 2022

IEPA Project No. L17-5882

November 23, 2021
Bid Set

Volume 2 of 3

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Bid Doc. No. 21-408

Four Rivers Sanitation Authority
Rockford, Illinois

Bidding Requirements and Contract Forms
and
General Provisions and Technical Specifications

for

Primary Filtration Project Phase I

Capital Project No. 2022
IEPA Project No. L17-5882

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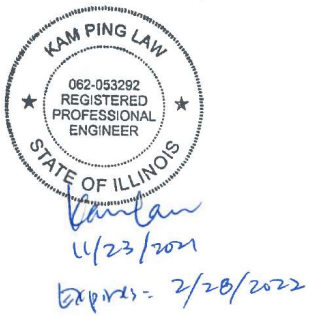
PROJECT MANUAL

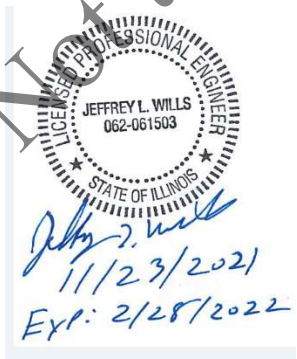
FOUR RIVERS SANITATION AUTHORITY
WASTEWATER TREATMENT PLANT

PRIMARY FILTRATION PROJECT (PHASE I)
CAPITAL PROJECT NO. 2022
IEPA LOAN NO. L17-5882

ROCKFORD, ILLINOIS

Seals and Signatures

Civil	Structural	Architectural	Process
			

HVAC/Plumbing	Electrical	Instrumentation and Controls
	 Date:11/23/2021 Exp:02/28/2022	

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ROCKFORD, ILLINOIS

TABLE OF CONTENTS

VOLUME 1

I. Bidding Requirements

II. Contract Forms

III. Federal, State, and Local Forms

IV. General Conditions and Supplementary Conditions

V. Technical Specifications

DIVISION 01 – GENERAL REQUIREMENTS

End of Volume 1

PROJECT MANUAL

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PRIMARY FILTRATION PROJECT (PHASE I)
CAPITAL PROJECT NO. 2022
IEPA LOAN NO. L17-5882

ROCKFORD, ILLINOIS

TABLE OF CONTENTS

VOLUME 2

V. Technical Specifications (Continued)

DIVISION 07 – THERMAL AND MOISTURE PROTECTION

DIVISION 08 – OPENINGS

DIVISION 09 – FINISHES

DIVISION 10 – SPECIALTIES

DIVISION 22 – PLUMBING

DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING

End of Volume 2

PROJECT MANUAL

FOUR RIVERS SANITATION AUTHORITY
WASTEWATER TREATMENT PLANT

PRIMARY FILTRATION PROJECT (PHASE I)
CAPITAL PROJECT NO. 2022
IEPA LOAN NO. L17-5882

ROCKFORD, ILLINOIS

TABLE OF CONTENTS

VOLUME 3

V. Technical Specifications (Continued)

DIVISION 31 – EARTHWORK

DIVISION 32 – EXTERIOR IMPROVEMEMTS

DIVISION 33 – UTILITIES

DIVISION 40 – PROCESS INTERCONNECTIONS

DIVISION 43 – PROCESS GAS AND LIQUID HANDLING EQUIPMENT

DIVISION 44 – ODOR CONTROL

DIVISION 46 – WATER AND WASTEWATER EQUIPMENT

VI. Appendix

End of Volume 3

DIVISION 03

CONCRETE

SECTION 03 08 10
TESTING TANKS AND RESERVOIRS

PART 1 – GENERAL

1.01 SUMMARY

A. Leakage testing of concrete wet wells, basins, tanks, and other structures which are to hold wastewater.

1.02 SUBMITTALS

A. Test results:

1. Records of tank testing indicating date of test, amount of leakage, amount of evaporation, corrective action if any, and retest results.

B. Submit in accordance with section 01 33 00.

1.03 PROCEDURES AND CRITERIA

A. Work shall conform to all requirements of ACI 350.1 except as modified by this Section.

B. Each cell of multi-cell structures shall be considered a single structure and tested individually unless otherwise specified.

PART 2 – PRODUCTS

(NOT USED)

PART 3 – EXECUTION

3.01 GENERAL

A. Contractor shall provide water for testing specified herein.

1. Groundwater or final effluent water from existing plant may be used.

2. Contractor shall coordinate discharge of test water with Owner.

B. Provide pumps and piping required to bring water to point of use.

3.02 PREPARATION

A. Structures shall be subjected to leakage tests after concrete has obtained specified design strength, and before backfilling or other Work which will cover faces of walls is begun.

B. Ground water level shall be brought to a level below the top of the base slab and kept at that elevation or at a lower elevation during the test.

C. No backfill shall be placed against the walls or on the wall footings of the structures to be tested, unless otherwise specified.

D. Tanks laterally restrained or supported by cross-walls, beams or slabs shall not be tested until such restraining or supporting construction is placed and has obtained its specified design strength.

E. Perform cleaning in accordance with section 01 74 00.

3.03 TESTING

A. Fill structure with water to elevations given in Table 03 08 10. The initial filling of the structure should not exceed a rate of 4 ft/hour.

B. After structure has been full for 72 hrs, it will be assumed for purposes of test that absorption of moisture by concrete in structure is complete. Measure change in water level at 24-hr intervals for test periods given in Table 03 08 10.

C. Fill 55-gal container with water and place next to or in structure being tested. Locate container so it experiences environmental conditions as close as possible to those experienced by structure. Container shall be used as an indicator to measure loss of water due to evaporation. Level of water in 55-gal container shall be measured and recorded over same period as structure.

D. If drop in water level, adjusted for evaporation in 24-hr period, exceeds 0.05% of volume of water contained in structure, leakage shall be considered excessive.

E. During test period, examine structure and mark visible leaks or damp spots.

F. Drain structure to 2-ft minimum below leaks and damp spots and repair. Method of repair shall be Contractor's option, subject to requirements of these Contract Documents and review by Engineer.

G. If leakage was determined to be excessive, refill structure to specified level and retest.

H. Continue this process until drop in water level in 24-hr period is less than 0.05% of volume of water in structure.

I. Repairs and additional tests shall be made by Contractor, in acceptable manner, at no additional cost to Owner.

TABLE 03 08 10
LEAKAGE TEST ELEVATIONS

Structure Name	Area Designation	Test Elevation	Test Period (days)
Primary Filtration Facility 1	001 – PFI Wet Well 1	707.00	5
Primary Filtration Facility 1	002 – PFI Channel 1	710.80	5
Primary Filtration Facility 1	004 – Primary Filter Tank 1	709.00	5
Primary Filtration Facility 1	005 – Primary Filter Tank 2	709.00	
Primary Filtration Facility 1	006 – PFE Channel 1	709.00	
Primary Filtration Facility 1	007 – PFE Channel 2	709.00	
Primary Filtration Facility 1	010 – Primary Filter Effluent Diversion Structure	709.00	
Primary Filtration Facility 1	009 – Scum Wet Well 1	707.00	5
Primary Filtration Facility 1	103 – Gravity Thickener 1	715.50	5
Primary Filtration Facility 1	104 – GTO Box 1	715.50	5
Primary Filter Distribution Box	Entire Structure	699.00	5
Primary Settling Tanks 1 and 2	Primary Influent Channel	702.25	5

END OF SECTION

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SECTION 03 11 16
ARCHITECTURAL CAST-IN-PLACE CONCRETE

PART 1 – GENERAL

1.01 SUMMARY

A. This section covers the work necessary for construction of the simulated limestone exposed concrete wall surfaces where noted on the drawings.

B. Construct textured and colored formed concrete surfaces using simulated stone masonry molds and color stain system designed to duplicate the appearance of the natural stone used at the site.

1.02 DESIGN REQUIREMENTS

A. Patterning of simulated stone masonry shall appear natural and non-repeating. Seam lines or match lines caused from two or more molds coming together will not be apparent when viewing final wall. Final coloration of cast stone concrete surface shall accurately simulate the appearance of real stone including the multiple colors, shades, flecking, and veining that is apparent in real stone. It shall also demonstrate the colors that may be apparent from aging, such as staining from oxidation, rusting and/or organic staining from soil and/or vegetation.

1.03 SUBMITTALS

A. Shop Drawings: Plan, elevation and details to show overall pattern, joint locations, form tie locations, and end, edge, and other special conditions.

B. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Manufacturer of simulated stone masonry molds and custom coloring system shall have five years experience making stone masonry molds and color stains to create formed concrete surfaces to match natural stone shapes, surface textures, and colors.

B. Pre-Installation Meeting shall be held with manufacturer representative to assure understanding of simulated stone masonry molds use, color application, requirements for construction of sample panel, and to coordinate the work.

1.05 PROJECT CONDITIONS

A. Environmental requirements: Apply color stain when ambient temperatures are between 50°F and 100°F. Consult manufacturer if conditions differ from this requirement.

B. Schedule color stain application with earthwork and back-filling of any wall areas making sure that all simulated stone texture is colored to the minimum distance below grade. Delay adjacent plantings until color application is completed. Coordinate work to permit coloring applications without interference from other trades.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. The specified systems are based on the Scott Form Liner by Scott System, Telephone (303) 373=2500 and Butterfield Color by Sika Brand, Telephone (800) 282-3388, or equal as approved by the Engineer.

2.02 MATERIALS

A. Simulated Masonry Molds: Reusable, made of high-strength urethane, easily attachable to forms. Molds shall not compress more than 1/4 inch when concrete is poured at rate of 10 vertical feet per hour. Molds shall be removable without causing deterioration of surface of underlying concrete. The wall mold pattern shall be as indicated below and at locations shown on Drawings:

1. Butterfield System Form Liner System BST9130 by Butterfield Color, Sika Brand.
2. Scott System Form Liner System 1500 by Scott System.
3. Scott System Form Liner System 1516 by Scott System.

B. Release Agent: Compatible with simulated stone masonry molds and with color stain system to be applied to surface. Consult manufacturers.

C. Form Ties: Shall conform to requirements of Section 03 30 00.

D. Color Stain: Special penetrating stain mix as provided by manufacturer, shall achieve color variations present in the natural stone being simulated for this project. Stain shall create a surface finish that is breathable (allowing water vapor transmission), and that resists deterioration from water, acid, alkali, fungi, sunlight or weathering. Stain mix shall be a water borne, low V.O.C. material, less than 180 grams per liter, and shall meet requirements for weathering resistance of 2000 hours accelerated exposure measured by weathertural stone being simulated for this project, as required by Engineer as referenced in DESIGN REQUIREMENTS. Color stain shall be applied by manufacturer or manufacturer's authorized representative.

1. Acceptable Manufacturer:

a. H&C Infusion Water-Based Semi-Transparent Decorative Concrete Stain by Sherwin-Williams or equal.

2. Stain Colors:

a. Stain color at Butterfield System Form Liner System BST9130 shall match Sherwin-Williams Color Sealskin SW7675 at Gravity Thickener walkway cap.
b. Stain color at Scott System Form Liner System 1500 shall match Sherwin-Williams Color Totally Tan SW6115.
c. Stain color at Scott System Form Liner System 1516 shall match Sherwin-Williams Color Latte SW6108.

E. Concrete Stain Sealer: Topcoat with low odor, water-based formula breathable sealer.

1. Acceptable Manufacturer:

a. H&C ClariShield Water-Based Wet Look Sealer by Sherwin-Williams or equal.

PART 3- EXECUTION

3.01 SAMPLE PANEL

A. Build on site, using same materials, methods and work force that will be used for the project. Engineer will determine specific requirements and location.

B. Size: 50 square feet, or larger if needed to adequately illustrate the patterns and textures selected.

C. Include an area to demonstrate wall mold butt joint and continuation of pattern through construction joint.

D. After concrete work on sample panel is completed and cured for a minimum of 28 days, and after surface is determined to be acceptable for coloring, apply color stain system.

E. Upon approval by Owner and Engineer, sample panel shall serve as quality standard for the project.

3.02 SPECIAL TECHNIQUES – FORMING TEXTURED CONCRETE

A. Simulated Stone Masonry Molds preparation: Clean and make free of buildup prior to each pour. Inspect for blemishes or tears. Repair if needed following manufacturer's recommendations.

B. Simulated Stone Masonry Molds attachments: Place stone molds with less than ¼ inch separation between them. Attach molds to form securely following manufacturer's recommendations.

C. Form release agent: Apply following manufacturer's recommendations.

D. Form stripping and related construction shall avoid creating defects in finished surface.

E. If the pattern selected has molds connecting through the middle of the stones, carefully remove the seam line created by abutting molds. Match the texture and shape of the surrounding stone, avoiding visible seams or mold marks.

F. Place form ties at thinnest points of molds (high points of finished wall). Neatly patch the hole remaining after disengaging the protruding portion of the tie so that it will not be visible after coloring the concrete surface.

G. Follow manufacturer's instructions at expansion joints.

H. Adjust mix design and/or placement of concrete techniques, as required, to achieve a finished surface free of bug holes that completely fills the form liner.

3.03 SPECIAL TECHNIQUES – APPLYING COLOR STAIN AND SEALER SYSTEM

A. All Simulated Stone surfaces that are to be stained and any patching that has been done in these areas shall be at least 30 days old.

B. Clean surface prior to application of stain materials to assure that surface is free of latency, dirt, dust, grease, efflorescence, paint, or other foreign material, following manufacturer's instructions for surface preparation. Do not sandblast. Preferred method to remove latency is pressure washing with water, minimum 3000 pounds per square inch (a rate of three to four gallons per minute), using fan nozzle perpendicular to and at a distance of one or two feet

from surface. Completed surface shall be free of blemishes, discoloration, surface voids and unnatural form marks.

C. Apply clear concrete sealer inaccordance with manufacturer's instructions.

3.04 PROTECTION

A. Where exposed soil or pavement is adjacent which may spatter dirt or soil from rainfall, or where surface may be subject to over spray from other processes, provide temporary cover of completed work.

END OF SECTION

SECTION 03 20 00
CONCRETE REINFORCING

PART 1 – GENERAL

1.01 SUMMARY

A. Provide concrete reinforcement where shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

1.02 REFERENCES

A. ACI: American Concrete Institute

B. ASTM: American Society for Testing and Materials

C. CRSI: Concrete Reinforcing Steel Institute

1.03 SUBMITTALS

A. Shop Drawings:

1. Conform to ACI SP-66 showing bending diagrams, assembly diagrams, location diagrams, splicing and laps of bars, shapes, dimensions, and details for reinforcing, and stirrup spacing, accessories, and additional reinforcing at openings.
2. Unless otherwise approved by Engineer, reinforcing for each individual structure shall be submitted separately.

B. Product Data:

1. Dowel Bar Splicer System, Reinforcing Bar Splicer, and Dowel Adhesive manufacturer's product data.

C. Submit in accordance with Section 01 33 00.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver reinforcement to site bundled and tagged.

B. Use necessary precautions to maintain identification after bundles are broken.

C. Store in a manner to prevent excessive rusting and fouling with dirt, grease, and other bond-breaking coatings.

1.05 AMERICAN IRON AND STEEL

A. This project is being funded with monies made available by the Safe Drinking Water Loan Program that has statutory requirements commonly known as "American Iron and Steel;" that requires that all of the iron and steel products used in the project to be produced in the United States ("American Iron and Steel Requirement"). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.

B. The Manufacturer shall provide with the shop drawing submittal one signed and dated original of the fully completed Certification Letter (a sample copy of which is provided in the Appendix of this

manual). Said form shall demonstrate compliance with Section 436 of federal H.R. 3547. Submit in accordance with Section 01 33 00

PART 2 – PRODUCTS

2.01 REINFORCEMENT MATERIALS AND ACCESSORIES

A. Deformed Steel Bars: ASTM A615, Grade 60.

B. Welded Wire Reinforcement: ASTM A1064.

C. Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcement in place:

1. Comply with CRSI recommendations.
2. For slabs on grade, use supports with sand plates or horizontal runners where base material will not support chair legs.
3. Exterior exposed surfaces, surfaces in contact with earth or liquid, and interior exposed surfaces in humid areas shall have all plastic or stainless steel supports.
4. Interior exposed surfaces in dry areas shall have all plastic, stainless steel, or plastic tipped steel supports.
5. When supports bear directly on the ground and it is not practical to use steel or plastic supports, solid precast concrete blocks may be used to support only the bottom mat of reinforcement. Precast blocks must be of equal or greater strength than the concrete being placed.

D. Dowel Adhesive:

1. Epoxy or acrylic adhesive.
2. Manufacturers:

a. HIT RE 500 V3 or HIT-HY 200-R System by Hilti Corp.
b. Pure 110+, AC100+ Gold or PE 1000+ by Dewalt.
c. SET-XP Epoxy or AT-XP Acrylic Adhesive System by Simpson Strong-Tie Co., Inc.
d. Red Head A7+, G5+ or C6+ by ITW Commercial Construction.

2.02 FABRICATION

A. Fabricate reinforcing bars to conform to the required shapes and dimensions and in accordance with ACI 318 and CRSI Manual.

B. In case of fabricating errors, do not straighten or rebend reinforcement in a manner that will weaken or injure the material.

C. Reinforcement with any of the following defects will not be acceptable.

1. Bar lengths, depths, and/or bends exceeding the specified fabrication tolerances.
2. Bends or kinks not shown on the Drawings.
3. Bars with reduced cross-section due to excessive rusting or other causes.

PART 3 – EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 INSTALLATION

A. Clean reinforcement to remove loose rust and mill scale, earth, and other materials which reduce or destroy bond with concrete.

B. Position, support, and secure reinforcement against displacement by formwork, construction, and concrete placing operations. Unless otherwise noted, provide clear cover as follows:

1. Cast against:

Earth: 3 inches
Mud Slab: 2 inches

2. Exposed to earth, weather, or water:

a. Slabs:

#5 Bars and smaller: 1 ½ inches
#6 through #11 Bars: 2 inches

b. Walls, Beams, and Columns: 2 inches

3. Not exposed to earth, weather, or water:

a. Slabs and Walls:

#3 through #7 Bars: 1 inch
#8 through #11 bars: 1 ½ inches

b. Beams and Columns: 1 ½ inches

C. Correct displacement of reinforcement prior to and during concrete placement. Maintain clear cover as noted on Drawings. Tolerances shall be in accordance with ACI 117 and ACI 318, unless noted otherwise.

D. Support reinforcing steel in accordance with CRSI “Placing Reinforcing Bars” with maximum spacing of 4 feet.

E. Tie reinforcing steel at intersections in accordance with CRSI “Placing Reinforcing Bars”.

1. Spacing for Footings, Walls, and Columns: Every third intersection, 3 feet maximum.
2. Spacing for Slabs and Other Work: Every fourth intersection, 3 feet maximum.
3. Tie each dowel in-place.

F. Reinforcement shall be continuous through construction joints.

G. Reinforcement may be sliced at construction joints provided that the entire lap is placed within only 1 pour.

H. Unless shown otherwise, place WWR between upper third point and mid point of slab. WWR placement on subgrade and pulling up during concrete placement not allowed.

I. Do not field bend bars, including bars partially embedded in concrete unless indicated.

J. Tack welding of, or to, reinforcement prohibited.

K. Placement of reinforcement shall be approved by Engineer before placing concrete.

L. Anchor dowels into drilled holes with epoxy dowel adhesive where noted. Conform to details shown.

3.03 SPLICES

A. Lap reinforcing at splices. Tie securely to prevent displacement of splices during placement of concrete.

B. Dowel Bar Splicer Systems may be substituted for dowels at Contactor's option when approved by Engineer.

C. Reinforcing Bar Splicers may be substituted for lapped splices at Contactor's option when approved by Engineer. Stagger splices.

D. Extend WWR to within 2 inches of edges of section. Lap sheets at least 12 inches at ends and edges and wire together. Stagger laps.

.

END OF SECTION

SECTION 03 30 00
CAST-IN-PLACE CONCRETE

PART 1 – GENERAL

1.01 SUMMARY

A. Provide cast-in-place concrete where shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

B. Provide an accelerated, high-early concrete used on 4 – Primary Filter Distribution Box to achieve compressive strength necessary to meet project schedule constraints.

1.02 REFERENCES

A. ASTM: American Society for Testing and Materials

B. NRMCA: National Ready Mixed Concrete Association

C. ACI: American Concrete Institute

D. AASHTO: American Association of State Highway and Transportation Officials

1.03 SUBMITTALS

A. Shop Drawings:

1. Verification of Mix Design:

a. Proposed mix design for each class of concrete to be used as specified using designations indicated. Provide dry weight of cement, saturated dry weight of coarse and fine aggregate, brand name and quantities of admixtures when applicable, fly ash when applicable, gallons of water required for 1 cubic yard of concrete, and chloride ion content.
b. Source and material certificates of cement and fine and coarse aggregate, including sieve analysis that will be used in each class of concrete.
c. Admixture product data.
d. Source and test reports of fly ash.
e. Source of blast furnace slag and documented ability of supplier to consistently furnish these materials in accordance with applicable ASTM and AASHTO requirements.
f. Test data supporting proportions of design mixes based on laboratory trial batches or past field experience in accordance with ACI 318.
g. NRMCA certification, IDOT certification, or letter stating plant and equipment complies with NRMCA or IDOT requirements.
h. Mix design shall be approved by Engineer before concrete delivered to site.

B. Product Data:

1. Waterstop: Samples of material and manufacturer's literature.
2. Curing Compound, Floor Sealer, and Evaporation Retardant: Proposed rate of coverage and manufacturer's literature.
3. Accelerator manufacturer's literature.
4. Finishing Grout manufacturer's literature.
5. Bonding Agent manufacturer's literature.
6. Fiber Reinforcement manufacturer's literature.

7. Patching Mortar manufacturer's literature.

C. Test Results:

1. Concrete test results.
2. Concrete delivery tickets: With each load of concrete delivered, provide duplicate tickets, one for Contractor, one for Engineer, with following information.

a. Serial number of ticket.
b. Date and truck number.
c. Name of supplier.
d. Class of concrete.
e. Type of cement and cement content in bags/cubic yard.
f. Admixture brand names.
g. Aggregate size.
h. Time loaded.
i. Amount of concrete in load.
j. Gallons of water added at site and slump of concrete after addition of water.
k. Temperature of concrete at delivery.
l. Time unloaded.

D. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Plant Certification: Plant or concrete supplier shall comply with requirements of NRMCA or IDOT certification plan as regards material storage and handling, batching equipment, central mixer, truck mixers with counters, agitators, nonagitating units, and ticketing system.

B. Do not commence placement of concrete until mix designs have been reviewed and approved by Engineer.

C. Concrete Testing: Testing shall be provided by Contractor in accordance with Section 01 45 29 and this Section.

1. Conduct tests on sample material in accordance with methods listed below:

a. Slump: ASTM C143.
b. Air-Entrainment: ASTM C231.
c. Compressive Strength: ASTM C31 and ASTM C39.

1.05 PROJECT / SITE CONDITIONS

A. Hot Weather:

1. Comply with ACI 305.1.
2. Concrete temperature shall not exceed 90°F.
3. At air temperatures of 80°F or above, keep concrete as cool as possible during placement and curing.
4. When concrete temperature exceeds 80°F, water reducing, set-retarding admixtures shall be used.

B. Cold Weather:

1. Comply with ACI 306.1.

2. Temperature of reinforcement, forms, fillers, and other material in contact with concrete at time of placement shall not be less than 35°F. Preheat if temperature below 35°F.
3. Maintain air and forms in contact with concrete sections having minimum dimension less than 12 inches at temperature above 50°F for at least 3 days and at temperature above 32°F for remainder of specified curing period.
4. Maintain air and forms in contact with concrete in more massive sections at temperature above 40°F for at least 3 days and at temperature above 32°F for remainder of specified curing period.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Cement:

1. Portland cement conforming to ASTM C150.
2. Type I/II or Type II
3. When aggregates determined to be deleteriously reactive, as defined by ASTM C33, alkali content of cement defined by ASTM C150 shall not exceed 0.60%.

B. Fly Ash:

1. ASTM C618, Class C or F including requirements of Table 1A.
2. Supplemental Requirements:

a. Loss on Ignition (maximum): 3%.
b. Water Requirement (maximum): 100% (as percent of control).
c. Fineness (maximum retained on No. 325 sieve): 25%.

C. Blast Furnace Slag:

1. Blast furnace slag shall conform to the requirements of ASTM C989 Grade 100 or 120.
2. Blast furnace slag from different sources or of different grades shall not be mixed in the same construction.

D. Aggregates:

1. ASTM C33, modified as follows:

a. Fine aggregate: Natural sand.
b. Coarse aggregate: Crushed gravel, crushed stone or gravel, Size 467 (1-1/2 inch maximum), size 67 (3/4 inch maximum), Size 8 (3/8 inch maximum).

2. Potential reactivity of aggregates shall be determined in accordance with ASTM C33.

E. Admixtures:

1. Air-Entraining: ASTM C260.
2. Chemical Admixtures: ASTM C494, non-corrosive and chloride free.
3. Accelerating Admixtures: ASTM C494, Type C, non-corrosive and chloride free.
4. Waterproofing Admixture:

a. C-500, C-500NF, C-1000, or C-1000NF by Xypex.
b. Aquafin IC Admix by Aquafin
c. Krystol Internal Membrane by Kryton
d. Penetron Admix by Penetron International Ltd.

e. Dosage: As recommended by manufacturer.

F. Water: Potable.

G. Premolded Joint Filler:

1. ASTM D 1751.
2. ASTM D1752, Type I, II, or III.
3. Closed cell polyethylene.

H. Waterstop:

1. Virgin polyvinyl chloride (PVC) waterstop conforming to CRD C572, with hog rings or grommets at 12 to 18 inches on center.
2. Construction Joints: Dumbbell or serrated type, 6 inches wide by 3/8 inch thick, at center, 4 inches wide by 3/16 inch thick only where noted.
3. Expansion Joints: Arctic grade, dumbbell or serrated type, 9 inches wide by 3/8 inch thick, at center, with 3/4 inch inside diameter hollow center bulb for joints less than 2 inches wide and 1-1/2 inch inside diameter hollow center bulb for joints 2 inches wide or wider.
4. Provide prefabricated tees, crosses, and other configurations as required.
5. Gasket Type Waterstop:

a. Hydrotite CJ-1020-2K by Greenstreak
b. MC-2010MN with P-201 by Adeka Corp.
c. AKWASTOP or WATERSTOP-XP by CETCO
d. 3/4 inch SikaSwell S-2 by Sika Corp.

I. Vapor Barrier: Polyethylene film minimum 10 mills thick.

J. Floor Sealer:

1. Manufacturers:

a. Dress and Seal 30 by L&M Construction Materials, Inc.
b. Tuf-Seal J-35 by Dayton Superior.

K. Membrane Forming Curing Compound:

1. Manufacturers:

a. Dress and Seal 30 by L&M Construction Materials, Inc.
b. MasterKure CC 200 WB by BASF.

2. ASTM C309, and compatible with scheduled finishes and coatings, except permeability shall not exceed 0.39 kilogram/meter^2/72 hours.

L. Finishing Grout

1. Manufacturers:

a. MasterSeal 581 by BASF.
b. Concrete Finisher with AKKRO-7T by Tamms Industries Co.
c. SikaTop Seal 107 by Sika Corp.

M. Cement Grout: Mixture of cement and fine sand in proportions used in concrete being finished.

N. Epoxy Bonding Agent:

1. Manufacturers:

a. Sikadur 32 Hi-Mod by Sika Corp.
b. Epoxtite 2362 by A.C. Horn.
c. Sure Bond J-58 by Dayton Superior.
d. Epobond by L&M Construction Materials, Inc.
e. Five Star Bonding Adhesive by Five Star Products, Inc.

2. Use when joining new to existing concrete.
3. Conforming to ASTM C881.

O. Non-Epoxy Bonding Agent:

1. Manufacturers:

a. Weld-Crete by Larsen Products Corp.
b. MasterEmaco A660 by BASF.
c. Acrylset by Master Builders Co.
d. Everbond by L&M Construction Materials, Inc.

2. Use when joining new to existing concrete when bonding agent cannot be placed immediately prior to placement of new concrete.
3. Conforming to ASTM C1059 Type II.

P. Evaporation Retardant:

1. Manufacturers:

a. Econ by L&M Construction Materials, Inc.
b. Confilm by Master Builders Co.
c. Sikafilm by Sika Corp.

Q. Fiber Reinforcement:

1. Manufacturers:

a. GCP Applied Technologies (W.R. Grace & Co.)
b. Fibermesh Co.
c. Euclid Chemical Co.
d. BASF

2. 1/2 inch to 3/4 inch collated fibrillated virgin polypropylene fibers.
3. ASTM C1116 Type III.

R. Patching Mortar.

1. Manufacturers:

a. Sikatop by Sika Corp.
b. Duratop by L&M Construction Materials, Inc.
c. MasterEmaco N 300 by BASF.

2. Polymer modified cementitious fast setting mortar for repair of concrete surfaces. Consisting of polymer and selected Portland cements, aggregates, accelerator,

admixtures for controlling set, water reducers for workability, and corrosion inhibitor. Shall contain no chlorides, nitrates, gypsum, or lime. Shall not produce vapor barrier. Shall be thermally compatible with concrete and shall be freeze-thaw resistant.

a. Concrete gray.
b. 5000 pounds per square inch minimum compressive strength.
c. 400 pounds per square inch minimum bond strength.

2.02 CONCRETE MIX DESIGN

A. Concrete Mix: Measure and combine cement, aggregate, water, and admixtures in accordance with ASTM C94 and ACI 211.1.

1. Cement: When used in exposed concrete shall be one brand from one source. Do not mix different cements in same element of Work.
2. Water-Cementitious Ratio (if fly ash or slag is used, water-cement plus fly ash and slag ratio): 0.42 maximum for Class A concrete, 0.50 maximum for Class B concrete.
3. Air-Entrainment: Air-entrain concrete exposed to exterior or exposed to liquids. Interior concrete floor with trowel-finished surface, limit air content to 3% max.
4. Chemical Admixtures: Use is optional to aid concrete properties and allow for efficient placement. Manner of use and amount shall be in accordance with manufacturer's written recommendations and as approved by Engineer. Do not use admixtures that increase early shrinkage or negatively affect finishing.
5. Fly Ash: Use is optional unless otherwise noted. Combine fly ash with cement at rate of 1 pound fly ash for each pound reduction of cement. Amount of fly ash shall not be less than 15% or more than 25% of weight of cementitious material.
6. Blast Furnace Slag: Use is optional unless otherwise noted. Combine blast furnace slag with cement at a rate of 1 pound blast furnace slag for each pound reduction of cement. Amount of blast furnace slag shall not be greater than 50% of weight of cementitious material.
7. Fly Ash and Blast Furnace Slag Combination: Use is optional unless otherwise noted. Combine fly ash and blast furnace slag with cement at a rate of 1 pound fly ash or blast furnace slag for each pound reduction of cement. Amount of fly ash and blast furnace slag combination shall not be greater than 50% of weight of cementitious material. Amount of fly ash shall not be greater than 25% of weight of cementitious material
8. Concrete for interior slabs reinforced with Welded Wire Reinforcement (WWR) and fillets in tanks shall be fiber reinforced.

    a. Dosage Rate: 1-1/2 pounds per cubic yard minimum.
    b. Use in strict accordance with manufacturer's written recommendation and ASTM C94.

9. Provide waterproofing admixture in the following areas:

    a. 4 – Primary Filter Distribution Box
    b. 5 – Primary Filtration Facility

10. Use no admixtures other than specified, unless approved by Engineer.

B. Class of Concrete:

1. Furnish in accordance with table. Cement contents listed are minimum values and shall be increased as required to attain other specified characteristics.
2. Slumps listed are maximum, except when high range water reducer is used. Maximum slump when high-range water reducer is used, 10 inches.
3. Chloride ion content shall not exceed values listed in ACI 318, Table 4.4.1.

4. Mid-range water reducer: ASTM C494, Type A required for Class A1 and A2 concrete.

Class	28-Day Compressive Strength (psi)	Coarse Aggregate (size no.)	Minimum Cementitious Material (lbs/cu yd)	Air Content (%)	Slump (in.)
A1	4500	467	517	5.5±1.5	3±1
A2	4500	67	564	6±1.5	3±1
B1	3000	467	423	5.5±1.5	3±1
B2	3000	67	446	6±1.5	3±1
B3	3000	8	470	7.5±1.5	4 max
C	2000	67	212	---	---
psi = pounds per square inch cu yd = cubic yard in. = inch max = maximum					
Note: Interior concrete floor with trowel-finished surface, limit air content to 3% max.					

C. Concrete Usage:

1. Class A: All locations, except where Class B and C specified.
2. Class B: Interior slabs reinforced with WWF, interior equipment bases, fence post piers, concrete fillets in tanks, and where specifically noted.
3. Class A1: Exterior unreinforced concrete pavement.
4. Class A2: Concrete curb and gutter and concrete sidewalk.
5. Class C: Mud slabs and backfill below and around structures where noted.
6. Do not use coarse aggregate Size 467 in sections 12 inches thick or less, where clear cover of reinforcement is less than 1-1/2 inches or where clear spacing between reinforcement bars is less than 3 inches.

2.03 MIXING AND DELIVERY

A. Use ready mixed concrete conforming to ASTM C94.

B. Deliver and complete discharge within 1-1/2 hours of commencing of mixing. Limitations may be waived by Engineer if concrete slump, after 1-1/2 hours, is sufficient so that concrete can be placed without addition of water. In hot weather, time criteria may be reduced by Engineer.

C. Do not add water on-site unless slump and water-cement ratio, after addition of water, is below maximum allowed.

D. Deliver concrete to site having temperature not less than 50°F or greater than 90°F.

PART 3 – EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 FORMS

A. Formwork design, detailing, and installation shall be Contactor's responsibility and shall conform to ACI 347.

B. Type of forms used is Contractor's option, except as other wise indicated or shown. Plywood and other wood surfaces shall have smooth, level surfaces treated with formoil or sealer to produce clean release of concrete from forms.

1. Where walls remain exposed use pylwood, prefabricated metal or wood forms; do not use boards.
2. Form ties shall be plastic cone snap ties. Cone shall be min 3/4 inch diameter by 1 inch deep. Ties for liquid holding structures or dry structures below grade shall have integral waterstop. Taper tie through-bolt form ties may be used as an alternate to plastic cone snap ties; conform to details shown. Do not use wire ties on exposed concrete.
3. Removal of ties shall leave holes clean cut and without appreciable spalling at face of concrete.
4. Provide 3/4 inch chamfer on external corners of exposed concrete walls, beams, columns, equipment bases and exposed edges of construction joints. Do not chamfer edges flush with masonry walls.
5. Provide openings at base of vertical forms as access for cleaning and inspection of forms and reinforcing prior to depositing concrete.

C. Coat plywood and wood forms with non-staining form release agent. Apply release agent before reinforcement is placed.

D. Clean, patch, and repair form material before reuse.

E. Formwork shall prevent leakage of mortar, shall not deflect under weight of concrete and workmen, and shall withstand fluid pressure of concrete.

F. Conform to tolerances as specified in ACI 117.

3.03 SUBGRADE PREPARATION

A. Subgrade and bedding shall be compacted and free of frost. If placement occurs at temperatures below freezing, provide temporary heat and protection to remove frost. Do not place concrete on frozen material.

B. Provide mud slabs where noted, where necessary, and when required by Engineer to obtain dry and stable working platform for placement of concrete. Unless otherwise approved by Engineer, 2 inch thick mud slabs shall be provided between free-draining fill and concrete as detailed.

C. Provide vapor barrier between subgrade and building floor slabs where noted, overlap joints minimum 6 inches.

D. Remove standing water, ice, mud, and foreign matter before placing concrete.

3.04 PLACING CONCRETE

A. Notify Engineer 24 hours in advance of placing operations.

B. Place concrete, except as modified herein, in accordance with ACI 304R.

C. Concrete will not be allowed to drop freely where reinforcing will cause segregation of mix.

1. Superplasticized Concrete: 10 feet maximum drop.
2. Other Concrete: 5 feet maximum drop.

D. If pumping used, do not use aluminum piping for delivery system.

E. When placing concrete temporarily halted or delayed, provide construction joints as shown and as specified.

F. Place in lifts not exceeding 24 inches and compact with internal mechanical vibrator equipment.

G. Minimum of 2 hours shall elapse after depositing concrete in columns or walls before depositing concrete in adjoining beams or slabs.

H. If in process of pouring wall, pour is stopped unexpectedly, leave surface of joint level but rough. Roughened surface shall have amplitude of 1/4 inch minimum. In water holding structures, before depositing new concrete against hardened concrete, retighten forms.

I. Provide bonding agent between new and hardened or existing concrete where shown. Existing concrete shall be sandblast cleaned to remove all foreign materials, to expose the coarse aggregate, and result in a roughened surface with minimum amplitude of 1/8 inch.

J. When hot and/or wind conditions will result in evaporation of 0.2 pounds per square foot per hour or more, evaporation retardant shall be used in accordance with manufacturer's written recommendations to minimize plastic shrinkage cracking.

3.05 JOINTS

A. Unless otherwise noted, construction joints shown are optional. Joints not shown on Drawings shall be approved by Engineer. Locate to miss splices in reinforcement.

B. Limit size of concrete pours. Maximum length of wall and slab pours shall not exceed 60.

C. Before concrete placed, construction joints shall be cleaned, laitance removed, and surface wetted. Remove standing water.

D. Locate construction joints in floors within middle third of span. Construction joints in floors supported by walls may be located at center of wall.

E. Construction joints in beams shall be offset minimum distance of 2 times width of intersecting beam.

F. Locate vertical joints in walls a min of one-half wall height from corners or other intersecting walls or at mid point between corners or intersecting walls. Locate horizontal joints in walls within the middle third of wall height.

G. Beams shall be placed monolithically as part of slab system, unless detailed otherwise.

H. Construction joints shall have roughened surfaces. Roughened surface shall have amplitude of 1/4 inch minimum.

I. Make control joints in slabs on grade of preformed control joint strips set flush with finished surface, by construction joint, by tooled joint, or cut 1/4 inch wide joints with diamond saw within 12 hours after placement.

1. Cut alternate reinforcing bars or wires crossing joint.
2. Control joints shall be minimum 1/4 depth of slab.
3. Fill construction joint, tooled joint, and sawed control joints with epoxy joint filler.

4. Unless otherwise indicated, spacing of control joints shall not exceed 24 feet in each direction.

J. Install premolded joint filler where noted in accordance with manufacturer's recommendations. Joint filler shall be compatible with sealant and suitable for intended purpose.

3.06 WATERSTOP

A. Provide waterstop in construction joints in:

1. Walls and slabs separating dry interior from earth or liquid.
2. Exterior walls and slabs of liquid holding tanks.
3. Slabs above occupied areas.
4. Other locations shown on Drawings.

B. Install in accordance with manufacturer's recommendations. Secure waterstop utilizing hog rings or grommets spaced maximum 12 in. on center and within 1 in. of edge. Wire tie bottom and top of waterstop to adjacent reinforcements prior to concrete placement. Secure as required to prevent deflection or misalignment during the concrete placement.

C. Splice joints in waterstop to form continuous watertight diaphragm. Splice in accordance with manufacturer's recommendations. Spark test joints as required by Engineer.

D. Use gasket type waterstop only where noted. Waterstop RX and MC-2010MN gasket type waterstops shall be glued and nailed to substrate.

3.07 EMBEDDED ITEMS

A. Cast pipe and other embedded items into concrete as placement progresses. Do not provide blockouts.

B. Following restrictions shall be adhered to, unless otherwise noted.

1. No duct, conduit, pipe, or fitting placed vertically shall be larger in cross-sectional area than 4% of column into which it is placed.
2. Duct, conduit, pipe, and fittings, when placed within slabs or walls

a. Shall not be larger than 1/3 thickness of slab or wall.
b. Shall be placed within the middle 1/3 thickness of slab or wall where possible.
c. Shall not be placed closer than 3 outside diameter clear from each other when parallel.
d. Shall cross each other at right angles.
e. Shall be secured to prevent shifting or "floating" during concrete placement.
f. Multiple conduits shall not cross each other at the same location.
g. Except for conduits that must run up a column, keep conduits a minimum of 2 to 3 feet away from columns.
h. Where conditions require conduit to be tied to the inside face of the reinforcing mat, the conduit shall be galvanized steel or PVC, shall not be tied directly adjacent to a parallel reinforcement bar, and shall be placed 3 outside diameter clear away from the parallel reinforcement bar.

3. Reinforcing steel shall be in place before embedded items placed and reinforcing cut or removed shall be replaced with additional reinforcing as indicated.
4. Do not pass sleeves through columns without Engineer's approval.

C. Do not place ducts, conduit, and pipes in slabs on grade. Place minimum 4 inches below slab.

D. Set items such as bolts, anchors, piping, and frames in concrete as shown.

E. Place items constructed of dissimilar metals to avoid physical contact with reinforcing. Secure item and reinforcing to ensure they will not shift and come into contact during concrete placement. Contact between reinforcing steel and other metal, other than bare, coated, or plated carbon steel not permitted.

3.08 REPAIR OF SURFACE DEFECTS

A. General:

1. Prior to starting repair work, obtain Engineer's approval of proposed repair techniques and materials.
2. Method of repair shall not adversely affect the appearance of the finished structure.
3. Develop repair techniques on portion of as-cast surface selected by Engineer. Surface of repair remaining exposed to view shall match color and texture of adjacent surfaces.
4. Prepare surfaces, apply and install materials, and cure as recommended by material manufacturers.

B. Tie Holes: Fill plastic cone snap tie holes with Patching Mortar. Fill taper tie through-bolt form tie holes with Non-Shrink Grout.

C. Defective Areas:

1. Remove honeycombing, stone pockets, spalls, and other defective concrete down to sound concrete. If chipping required, make edges perpendicular to surface. Do not feather edges.
2. Fill defective area with Patching Mortar.

D. Leaks or Wet Spots:

1. Inject, patch and repair areas where leaks or wet spots have occurred inside dry structures.
2. Inject, patch and repair areas where leaks or wet spots have occurred in wet wells, basins, tanks, and other structures which are to hold water in accordance with Section 03 08 10.

3.09 FINISHING SLABS AND FLATWORK

A. Slab Finishes:

Description	Concrete Finish
Surfaces to Receive Grout or Topping	Float
Submerged and Buried Slabs	Float
Sealer Applied Floors and Slabs	3 Trowelings
Exterior Exposed Slabs	Float and Broom Finish
Exterior Stairs and Walks	Float and Broom Finish
Interior Stairs	I Troweling and Broom Finish

B. After placement, screed concrete with straightedges, power strike-offs or vibrating screeds.

C. After screeding, bull float or darby surfaces to eliminate ridges and to fill in voids left by screeding.

D. Float:

1. Use magnesium or aluminum hand floats or power floats with slip on float shoes.
2. Float finish shall result in uniform smooth granular texture.

E. Trowel:

1. Use steel trowels.
2. Use power or hand troweling.
3. Final troweling shall be by hand and continue until concrete surface consolidated to uniform, smooth, dense surface free of trowel marks and irregularities.

F. Broom Finish: Use fine, soft-bristled broom and broom at right angles to direction of traffic to give nonskid finish approved by Engineer.

G. Floor Sealer:

1. Apply in accordance with manufacturer's written instructions.
2. Apply first cost after final troweling, surface water glaze has dissipated, and when surface is hard enough to sustain foot traffic on same day as pour.
3. When floor has been water cured, apply first coat after curing has been completed. Apply within one day of floor being dry enough for application.
4. Apply second coat after Work completed and ready for occupancy.

H. For special coatings or finishes, see room finish schedule.

I. Tolerances:

1. Concrete slabs shall be within 3/16 inch of 10 foot straightedge in all directions except where slabs are dished for drains. Deviations from elevation indicated shall not exceed 3/4 inch.
2. Pitch floor to floor drains minimum 1/8 inch per foot or as shown. Pitch bottom of slab or beam to match top slope to maintain thickness or depth indicated. As an alternate, bottom of slab or beam may be placed level provided that min thickness or depth is maintained.

3.10 FINISHING FORMED CONCRETE

A. As-Formed Finish: Finish resulting directly from formwork for surfaces which will be hidden from view by earth, submergence in water, or subsequent construction.

1. Repair surface defects as specified herein.
2. Where joint marks or fins on submerged surfaces exceed 1/4 inch, grind smooth.

B. Smooth Finish: Interior concrete surfaces permanently exposed to view and concrete surfaces scheduled to be coated.

1. Repair surface defects as specified herein.
2. Grind joint marks and fins smooth with adjacent surface. Remove stains and rinse.
3. Dampen concrete and paint entire surface with Cement Grout. Work grout into surface with suitable float. When grout has set to where it will not be pulled out of holes or depressions, brush off surface with burlap or carpet.
4. Prepare surface to be coated in accordance with Section 09 96 00 and coating manufacturer's recommendations.

C. Rubbed Finish: Exterior concrete surfaces permanently exposed to view extending to 6 inch below finished grade or liquid level.

1. Repair surface defects as specified herein.
2. Grind joint marks and fins smooth with adjacent surface. Remove stains and rinse.
3. Apply heavy coat of Finishing Grout. After first coat has set, apply second coat. When second coat has set, float to uniform texture.
4. Follow manufacturer's written recommendations.
5. Finish color shall be gray unless noted otherwise. Owner shall select final finish color of concrete.

3.11 PROTECTION AND CURING

A. Protect concrete from frost and keep moist for min curing period of 7 days after placement in accordance with ACI 308.

B. Formed Surfaces:

1. Wet cure by spraying surfaces as frequently as drying conditions may require to keep concrete surfaces moist.
2. Surfaces may be cured by leaving forms in-place. For vertical surfaces, apply water to run down inside of forms, if necessary, to keep concrete moist.
3. After forms are removed, wet cure for remainder of curing period or apply curing compound.
4. Do not use curing compound where mortar, grout, concrete, or other coatings or adhesives will be applied.

C. Flatwork:

1. Cure using curing compound or wet cure.
2. Do not use curing compound where mortar, grout, concrete, or other coatings or adhesives will be applied.

D. Curing Compound:

1. Apply curing compound at uniform rate sufficient to comply with requirements for water retention as specified and as measured in accordance with ASTM C156.
2. Cover areas subjected to direct sunlight with ambient temperature expected to exceed 80°F with white pigmented compound, other surfaces may be covered with fugitive dye compound.

E. Protect from damaging mechanical disturbances, load stresses, heavy shock, and excessive vibration.

F. Protect finished concrete surfaces from damage caused by construction equipment, materials, and methods, and from rain or running water.

G. Do not load self-supporting structures to overstress concrete.

3.12 REMOVAL OF FORMING AND SHORING

A. Do not remove forming or shoring until member supported has acquired sufficient strength to safely support own weight and any imposed loads. Forming shall remain in place for at least min time recommended by ACI 347. In addition, forming for horizontal members shall remain in place minimum 7 days. In no case shall forming for horizontal members be removed before concrete has reached 70% of specified design strength.

B. Reshore areas as required to carry additional imposed loads.

3.13 FIELD QUALITY CONTROL

A. Obtain samples of concrete in accordance with ASTM C172. Place cylinders on-site where they can be stored under conditions similar to concrete they represent without being disturbed for first 24 hours.

B. Make slump tests daily and when requested by Engineer, in accordance with ASTM C143. Make slump tests from same load from which strength tests are made.

C. Make air content tests daily and when requested by Engineer, in accordance with ASTM C231. Make air content tests from same load from which strength tests are made.

D. If measured slump or air content falls outside specified limits, make check test immediately on another portion of same sample. In event of second failure, concrete shall be considered to have failed to meet requirements of Specifications and will be rejected.

E. Make strength test for each of the following conditions for each class of concrete

1. Each day's pour.
2. Each change of source.
3. Each 100 cubic yards poured.

F. Strength test for each class of concrete consists of 4 cured standard cylinders made from composite samples secured from same load of concrete in accordance with ASTM C172. Make compressive strength tests on 1 cylinder at 7 days and 2 cylinders at 28 days. Test results at 28 days shall be average strength of 2 specimens as determined in accordance with ASTM C39. Test remaining cylinder if needed.

1. When temperatures are expected to fall below 45°F within 48 hours after concrete placement, make 2 additional cylinders and cure in the field under conditions similar to concrete they represent. Test 1 cylinder at 7 days and the other at 28 days.

G. Strength of concrete considered satisfactory if following requirements met.

1. Average of all sets of 3 consecutive strength tests equal or exceed specified 28-day compressive strength.
2. No individual strength test falls below specified 28-day compressive strength by more than 500 pounds per square inch.

H. If analysis of strength tests indicate above requirements are not being met, make immediate adjustments to mix design and make additional tests as required by Engineer to determine strength of concrete in-place in portion of structure represented by deficient cylinders. If tests verify Work in-place is not in conformance with Specifications, Engineer will determine if Work in-place is adequate for intended use. If Work in-place is determined to be inadequate, Contractor shall follow such remedial or replacement measures which Engineer may require. Contractor shall bear costs associated with testing, engineering analysis, remedial work, and replacement required under terms of this paragraph.

END OF SECTION

SECTION 03 40 00
PRECAST CONCRETE

PART 1 – GENERAL

1.01 SUMMARY

A. Provide precast prestressed concrete roof members where shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

1.02 REFERENCES

A. ACI: American Concrete Institute

B. PCI: Precast Concrete Institute

C. ASCE: American Society of Civil Engineers

1.03 SYSTEM DESCRIPTION

A. Precast manufacturer shall be responsible for structural design of individual precast prestressed components and connections between components.

B. Design, reinforce, and prestress units as required by ACI 318, PCI Design Handbook, local building code, and as specified herein.

C. Design and provide members capable of supporting superimposed loads shown on Drawings including following:

1. Roof Live Load: 20 pounds per square foot.
2. Roof Snow Load:

    a. 30 pounds per square foot snow.
    b. Increased snow loads (drift) in accordance with ASCE 7. See drawings for snow drift diagram.

3. Roofing Dead Load: 10 pounds per square foot.
4. Roof and ceiling mounted mechanical equipment and piping.
5. Dead Load: Weight of the structure plus additional loads as noted.
6. Wind Load: Vult = 120 miles per hour, Vasd = 93 miles per hour.
7. Seismic Load in accordance with ASCE 7.
8. Load combinations in accordance with ASCE 7 or ACI 318.

D. Provide 1-1/2 hour UL fire resistance rated units unless otherwise noted.

E. Conform to the shapes indicated.

1.04 SUBMITTALS

A. Shop Drawings:

1. Content:

    a. Dimensions.
    b. Design loads.

c. Design camber.
d. Fabrication details.
e. Details of inserts, anchors, connections, accessories, joints, and openings.
f. Chamfer and radius of corners.
g. Reinforcement and tendons.
h. Welds.
i. Finishes.
j. Lifting positions and devices.

2. Erection drawings including piece numbers and table referencing piece numbers to standard unit designations.
3. Stamped by Structural Engineer registered in State of Illinois.

B. Product Data:

1. Catalog or table information for standard precast units.

C. Miscellaneous Submittals:

1. Evidence of certification or experience qualifications, when requested by Engineer.

D. Submit in accordance with Section 01 33 00.

1.05 QUALITY ASSURANCE

A. Conduct testing in accordance with PCI MNL-116.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Follow manufacturer's written instructions for handling and storage.

B. Store units at the job site in a manner to prevent cracking, distortion, warping, staining, and other physical damage, and in a manner to keep markings visible.

C. Lift and support the units only at designated lifting points or supporting points as shown on the approved Shop Drawings.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Firms specializing in providing precast prestressed concrete products and services normally associated with industry for at least 3 yrs.

B. Manufacturers meeting requirements of PCI MNL-116.

C. Manufacturers may be required to submit written evidence showing experience, qualifications, and adequacy of plant, facilities, and ability to perform Work.//

2.02 MATERIALS

A. Portland Cement: ASTM C150, Type I, II, or III.

B. Admixtures:
1. Air-Entraining: ASTM C260.

2. Chemical: ASTM C494, non-corrosive and chloride free.

C. Aggregates:

1. ASTM C33.
2. Natural materials.
3. Maximum 3/4 inch.

D. Water: Potable.

E. Reinforcing Steel:

1. Deformed Steel Bars: ASTM A615, Grade 60.
2. Welded Wire Fabric: ASTM A185.
3. Fabricated Steel Bar Mats: ASTM A184.

F. Fiber Reinforcement:

1. Manufacturers:

a. W.R. Grace & Co.
b. Fibermesh Co.
c. Euclid Chemical Co.

2. 1/2 inch to 3/4 inch collated fibrillated virgin polypropylene fibers.
3. ASTM C1116 Type III.

G. Tendons: Uncoated, stress-relieved strand, ASTM A416, Grade 250K or 270K. Low relaxation strand conforming to Supplement 1 may be used.

H. Anchors and Inserts:

1. ASTM A36 or ASTM A307. Manufacturer's standard primer.
2. Types as indicated on the Drawings or as approved by Engineer.

I. Cement Grout: One part Portland cement and 3 parts sand.

J. Bearing Pads:

1. Hollow Core Plank: 1/8 inch thick tempered hardboard or high-density plastic.

K. Welded Studs: AWS D1.1.

L. Joint Sealants and Accessories: Conform to requirements of Section 07 92 00.

2.03 MIX DESIGN

A. Mix design shall be in accordance with manufacturer's recommendations.

B. Concrete Properties:

1. 28-Day Compressive Strength:

a. Minimum 4000 pounds per square inch for hollow core plank.

2.04 FABRICATION

A. Formwork:

1. Construct forms to maintain units within specified tolerances with radius or chamfer corners.
2. Locate lifting devices to not harm appearance of unit in finished position.
3. Form treatments or curing compounds shall not contain ingredients which might stain concrete or reduce bond with subsequent coatings, finishes, etc.

B. Reinforcement:

1. Pretension tendons in accordance with PCI MNL-116.
2. Provide reinforcement necessary to resist applied loads, handling and erection.

C. Locate lifting devices to not harm appearance of unit in finished position.

D. Accurately and rigidly position embedded items during concrete placement. Avoid contact of dissimilar metals.

E. Batch, mix, and handle concrete in accordance with ACI and PCI recommendations.

F. Cure units in accordance with PCI MNL-116.

G. Detensioning:

1. Detension units after concrete has reached release strength in accordance with design.
2. If heat cured, perform detensioning while unit is still warm.
3. Detension tendons in gradual sequence to prevent shock and unbalanced loads.

H. Finishes:

1. Unexposed Areas: As cast.

2. Interior Exposed Faces of Roof Plank (Dry Cast Units):

   a. Cast against concrete or steel casting beds maintained in accordance with industry practice.
   b. Surface holes, chips, and spalls shall not exceed 1/4 inch.
   c. Casting bed offsets and finish shall not exceed 1/8 inch.

3. Permanently exposed surfaces shall be consistent in appearance over entire area. Spotty coloring not accepted.

4. Field coated / stained as specified in section 09 96 00.

I. Fabrication tolerances shall conform to requirements of PCI MNL-116.

1. Edges of units shall be true and parallel and not vary from a straight line more than 1/8 inch at any point.
2. Edges shall be parallel within maximum variation of 1/8 inch at any point.
3. Faces shall not vary from flat plane more than 1/8 inch at any point.
4. Maximum warpage prior to installation shall not exceed that which can be corrected during installation.

2.05 ANCHORS, HOLES, AND FRAMING

A. Provide pipes, sleeves, inserts, weld plates, anchor plates, anchor bolts, bolts, concrete anchors, and other embedded items shown and as required. Place dissimilar metals to avoid physical contact between them.

B. Furnish inserts, plates, fastening devices, and anchors to be set in supporting structure.

C. Provide anchor straps, plates, angles, bolts, and other items as required to connect individual members to each other and supporting structure.

D. Holes shall be formed during manufacture of units, or field cut or cored. Location shall be coordinated with manufacturer. Do not cut tendons without manufacturer's consent. Over cutting will not be allowed. Edges of holes shall be neat and square, spalled edges will not be allowed.

E. Large Openings:

1. Design and provide steel headers.
2. Reinforce units adjacent to units with large openings to support additional dead and live load caused by opening.

F. At holes and along cut edges of hollow core units, exposed cores shall be grouted solid within 6 inches of hole or cut edge.

2.06 CLOSURES

A. Provide precast concrete closure panels between stems of tees.

2.07 SOURCE QUALITY CONTROL

A. Comply with applicable requirements of PCI MNL-116.

1. Make one compression test for each day's production of each type of member.
2. Test cylinders and absorption specimens shall be cast from the same materials and by the same methods as the precast units, and shall be cured in the same manner as the precast units.
3. Compression test shall conform to ASTM C39.

B. Failure of any member to come within tolerances specified herein shall be cause for rejection.

PART 3 – EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 INSTALLATION

A. Erect units in accordance with manufacturer's written instructions.

B. Do not bear units on cast-in-place concrete or masonry construction until support has reached 80% of design strength.

C. Provide bearing pads set on level and uniform bearing surfaces.

D. Do not place warped, cracked, or broken units.

E. Ends of units may be saw cut if required for proper clearance. Do not break units with hammer to produce proper clearance.

F. Set units straight, level, plumb, and square.

G. Provide temporary supports and bracing as required to maintain position, stability, and alignment until units are permanently connected.

H. Perform welding in accordance with AWS D1.1 and AWS D1.4.

I. Remove lifting devices and grout flush with adjacent surface.

J. Repair damaged surfaces to match adjacent surfaces.

K. Connect and anchor units to each other and other structural elements as shown and in accordance with approved shop drawings.

L. Anchor hollow core units to supporting members as shown. When approved by Engineer, anchors may be drilled and grouted into supporting structure.

M. Erection Tolerances:

1. Roof Plank:

a. Alignment between units and along other structural elements: Maximum 1/8 inch per 10 feet, vertical and horizontal.
b. Elevation between adjacent roof or floor members: Maximum difference 3/4 inch at any point.
c. Gaps between adjacent roof or floor units: Maximum 1/4 inch.

3.03 GROUTING, POINTING, AND CAULKING

A. Roof Units: Grout joints between hollow core floor and roof units from top of unit, and finish on underside before hardening as follows:

1. Where units to be exposed or painted as finished ceiling: Rake joints 1/2 inch deep and fill with sealant, finish smooth.
2. Unexposed areas and areas with suspended ceilings: Rough formed or rough broomed.
3. Trowel top of grout joints on roofs smooth to prevent unevenness interfering with placing of, or causing damage to, insulation or roofing. Slope due to differential elevations shall not exceed 1:12.

3.04 CLEANING

A. Clean exposed surfaces with water, rinse thoroughly.

END OF SECTION

SECTION 03 53 00
CONCRETE TOPPING

PART 1 – GENERAL

1.01 SUMMARY

A. Cast-in-place concrete topping leveling grout in tanks.

1.02 REFERENCES

A. ASTM: American Society for Testing and Materials

B. ACI: American Concrete Institute

1.03 SUBMITTALS

A. Test Results:

1. Topping test results.

B. Miscellaneous Submittals:

1. Statement by topping supplier giving source and material certificates, and proportions by weight of cement, fine and coarse aggregate, and admixtures.

C. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Testing shall be provided by Contractor in accordance with Section 01 45 29 and this section.

B. Perform slump tests (ASTM C143), air-entrainment tests (ASTM C231), and compressive strength tests (ASTM C31 and ASTM C39) daily.

1.05 PROJECT / SITE CONDITIONS

A. At time of placement, difference in temperature between topping and receiving surface shall not exceed 10°F.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Portland Cement: ASTM C150, Type II, except tricalcium aluminate (C_3A) content shall not exceed 12%.

B. Aggregate:

1. ASTM C33.
2. Fine aggregate shall be natural sand.
3. Coarse aggregate shall be crushed stone or gravel, Size 8 (3/8 inch maximum).

C. Epoxy Bonding Agent: In accordance with Section 03 30 00.

D. Air-Entraining Admixture: ASTM C260.

E. Chemical Admixtures: ASTM C494, non-corrosive and chloride free.

F. Fiber Reinforcement:

1. Manufacturers:

a. W.R. Grace & Co.
b. Fibermesh Co.
c. Euclid Chemical Co.

2. 1/2 inch to 3/4 inch fibrillated virgin polypropylene fibers.
3. ASTM C1116 Type III.

2.02 MIX DESIGN

A. Mixture:

1. 590 pounds per cubic yard minimum cement.
2. Fine and coarse aggregate as required.
3. Air content: 7±1%.

B. 28-Day Compressive Strength: 4000 pounds per square inch.

C. Slump: 2 to 4 inches. High range water reducer may be used to increase workability.

D. Fly ash may be substituted for part of cement in accordance with Section 03 30 00.

E. Topping shall be fiber reinforced.

1. Dosage Rate: 1-1/2 pounds per cubic yard minimum.
2. Super plastizer admixture required.
3. Use in strict accordance with manufacturer's written recommendation and ASTM C94.

PART 3 – EXECUTION

3.01 SURFACE PREPARATION

A. Surface shall be free of oil, grease, paint, or other foreign materials that will reduce bond.

B. For Tank Slabs:

1. Acid etch surface with muratic acid.
2. Wet surface before applying acid to dilute and distribute acid.
3. As soon as foaming has stopped, flush surface with water until it reacts neutrally to pH paper.

C. Bonding to Base:

1. Thoroughly wet surface just prior to placing topping. Remove standing water.
2. Broom thin coat of neat cement grout into surface.
3. In lieu of neat cement grout, delete acid etching required above and apply bonding agent in accordance with manufacturer's recommendations.

3.02 PLACING AND FINISHING

A. Placing:

1. Place topping, except as modified herein, in accordance with ACI 304R.
2. For tank slabs screed in-place with assistance of equipment.

B. Finishing:

1. Float and 2 trowelings required.
2. Finish to smooth surface free from defects and blemishes.

3.03 PROTECTION AND CURING

A. Comply with requirements of Section 03 30 00.

END OF SECTION

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SECTION 03 62 00
NON-SHRINK GROUTING

PART 1 – GENERAL

1.01 SUMMARY

A. Cement based grout for setting equipment base plates.

1.02 RFERENCES

A. ASTM: American Society for Testing and Materials

1.03 SUBMITTALS

A. Product Data:

1. Manufacturer's literature.

B. Submit in accordance with Section 01 33 00.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Manufacturers:

1. Five Star Grout by Five Star Products, Inc.
2. SET Grout by BASF.
3. Duragrout by L&M Construction Chemicals, Inc.
4. SikaGrout 212 by Sika Corp.

B. Grout:

1. Preblended, cement based, nonmetallic, nongas forming, nonshrink and shall not bleed.
2. Comply with ASTM C1107 and CRD C621, Grade B.
3. Moderate fluidity.
4. 5000 pounds per square inch minimum compressive strength.

C. Water: Potable.

PART 3 – EXECUTION

3.01 PREPARATION

A. Clean grout contact surfaces of oil, grease, scale, and other foreign matter.

B. Chip away unsound concrete leaving surface rough but level.

C. Clean base plates, rails, anchors, bolts, etc. in contact with grout of oil, grease, dirt, and coatings.

3.02 MIXING AND PLACING

A. Mix and place in accordance with manufacturer's written instructions.

B. Provide forming materials where necessary to retain grout until hardened.

C. Work grout from one side. Avoid trapping air under base plate.

D. Do not load grout until it has reached a minimum of 3000 pounds per square inch compressive strength.

3.03 CURING

A. Cure as recommended by grout manufacturer.

END OF SECTION

DIVISION 04

MASONRY

SECTION 04 21 13
BRICK MASONRY

PART 1 – GENERAL

1.01 SUMMARY

A. Provide clay brick masonry where shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

1.02 REFERENCES

A. ASTM: American Society for Testing and Materials

B. ACI: American Concrete Institute

1.03 SUBMITTALS

A. Shop Drawings:

1. Source, material certificates, and proportions by weight of cement, fine aggregate, and admixtures for mortar.

B. Product Data:

1. Brick cleaner manufacturer's literature.
2. Flashing manufacturer's literature.
3. Weephole manufacturer's literature.

C. Samples:

1. Brick.
2. Flashing.

D. Test Results:

1. Mortar test results.

E. Miscellaneous Submittals:

1. Material certification for brick units. Test data shall not be more than 5 years old.

F. American Iron and Steel Compliance Certification:

1. This project is being funded by the Clean Water State Revolving Fund that requires that all of the iron and steel products used in the project to be produced in the United States ("American Iron and Steel Requirement"). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R. 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.
2. The Manufacturer shall provide with the shop drawing submittal one signed and dated Certification Letter (a sample copies of which are provided in the Appendix). The Certification Letter shall demonstrate compliance with Section 436 of federal H.R. 3547.

G. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Testing:

1. Testing shall be provided by Contractor in accordance with Section 01 45 29 and this section.
2. Before construction starts, tests shall be made on laboratory prepared mortar using job materials and proportions. Results shall conform to ASTM C270.
3. Before construction starts, test job-mixed mortar in accordance with ASTM C780 and correlate results with laboratory prepared mortar. Perform consistency, water-content, air-content, and compressive strength tests.
4. During construction, test mortar weekly in accordance with ASTM C780.

B. Sample Panel:

1. 6 feet long by 4 feet high panel showing:

a. Face brick, calcium silicate masonry units (rock and smooth face) and concrete masonry units.
b. Color range.
c. Texture range.
d. Bonding.
e. Mortar color.
f. Tooled joints.
g. Quality of workmanship.

2. Do not start Work until Engineer has accepted sample panel.
3. Use panel as standard of comparison. Failure of masonry work to meet or exceed quality of work depicted by sample panel shall be cause for rejection.
4. Do not destroy or move panel until Work completed and accepted by Owner.
5. When approved by Engineer, sample panel may be incorporated into finished work.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store masonry units above ground on level platforms which allow air circulation under the stacked units.

B. Cover and protect against wetting prior to use.

1.06 PROJECT / SITE CONDITIONS

A. Cold Weather Protection:

1. Temperature of masonry units shall not be less than 32°F when laid.
2. When air temperature falls below 40°F or when temperature of masonry units is below 40°F:

a. Remove visible ice on masonry units before unit is laid.
b. Heat mortar sand or mixing water to produce mortar temperature between 40°F and 120°F.
c. When air temperature is between 25°F and 40°F, completely cover masonry by covering with weather resistant membrane for 24 hours after construction.

d. When air temperature is between 20°F and 25°F, use heat sources, install wind breaks when wind velocity exceeds 15 miles per hour, and completely cover masonry with insulating blankets for 24 hours after construction.
e. When air temperature is below 20°F, provide enclosure and use heat source to maintain temperature within enclosure above 32°F for 24 hours after construction.

B. Hot Weather Protection:

1. When air temperature exceeds 100°F, or 90°F with wind velocity greater than 8 miles per hour:

a. Do not spread mortar more than 4 feet ahead of masonry.
b. Set units within 1 minute of spreading mortar.

PART 2 – PRODUCTS

2.01 MORTAR AND GROUT

A. Materials:

1. Portland Cement: ASTM C150, Type I.
2. Masonry Cement: ASTM C91, Type S.
3. Lime: Hydrated lime, ASTM C207, Type S.
4. Sand: ASTM C144, acceptable in color, 10% passing No. 100 sieve.
5. Water: Potable.
6. Coloring Pigments: Commercial iron oxide, manganese dioxide, or chromium oxide of color selected by Engineer.
7. Do not use antifreeze compounds.
8. Do not use water repellant admixture.

B. Proportions: ASTM C270, property specification Type S (1800 pounds per square inch).

2.02 BRICK MASONRY UNITS

A. Face Brick:

1. Standard size units conforming to ASTM C216, Grade SW, Type FBX.
2. Provide specials shapes where indicated on Drawings, and as required for complete and proper installation.
3. Face brick shall be Browerston standard modular brick 85/15 Vertex STD.

a. Color: Buffs and tans. Very light flashed.

2.03 WEEPHOLE MATERIAL

A. Manufacturer:

1. William Goodco Brick Vent by William Products, Inc.

B. Offset "T" shape brick vent with vertical leg, slotted to allow air passage while preventing water passage and top flap designed to keep mortar out. Vent shall be designed for full height of brick.

2.04 MORTAR CATCHER

A. Manufacturers:

1. Mortar Trap by Hohmann & Barnard, Inc.
2. MortarNet by Mortar Net Solutions.

B. Mesh material placed in the wall cavity to prevent mortar droppings from blocking weep holes.

2.05 FLASHING

A. Rubberized asphalt sheet flashing with metal drip edge.

B. Sheet Flashing:

1. Perm-A-Barrier as manufactured by W. R. Grace & Co.
2. Dur-O-Barrier as manufactured by Dur-O-wall.
3. A self-sealing, self-healing, fully adhered composite flexible, self-adhesive, cold applied sheet consisting of a minimum of 32 mils of rubberized asphalt bonded to an 8 mil high density cross laminated polyethylene film.

C. Metal drip edge shall be 26 gauge 304 stainless steel sheet. Drip edge shall be minimum 2 ½ inches wide with 5/8 inch 135 degree drip and minimum 1/4 inch hem along outside edge.

D. Accessories: Primer, conditioner, adhesive, and mastic compatible with the sheet flashing as recommended by the sheet flashing manufacturer.

2.06 BRICK CLEANER

A. Manufacturers:

1. Sure Klean.

B. As recommended by brick manufacturer.

PART 3 – EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 BRICK MASONRY UNITS

A. General:

1. Use only brick that are clean and free of dust and other foreign matter.
2. Use masonry saws to cut and fit masonry units.
3. Set units plumb, true to line, with level courses accurately spaced, and with square angles and corners.
4. Clean the top surface of foundation free from dirt and debris prior to start of installing first course.
5. Where brick are moved or shifted, remove and lay again on fresh mortar.

B. Wetting:

1. Brick which have an initial rate of absorption (suction) greater than 30 grams per 30 square inch per minute, as measured in accordance with ASTM C67, shall be wetted prior

to laying except when air temperature falls below 40°F or when temperature of units is below 40°F.
2. Use wetting method which will assure each unit is nearly saturated but surface dry when laid.

C. Unless otherwise shown on the Drawings, provide running bond with vertical joints located at center of masonry units in the alternate course below.

D. Do not use chipped or broken units. If such units are discovered in the finished wall, Engineer may require their removal and replacement with new units at no additional cost to the Owner.

E. Laying up:

1. Place units in mortar with full bed and head joints.
2. Where brick laid against cast-in-place or precast concrete, provide vertical dovetail anchor slots at 2 feet on center, with dovetail anchors at 16 inches on center.
3. Where brick laid against concrete masonry units, provide horizontal joint reinforcement in accordance with Section 04 22 00.

F. Tooling:

1. Tool joints to a dense, smooth surface.
2. Unless otherwise shown on the Drawings, provide joints of "concave" pattern throughout.
3. Brush with soft brush to remove projecting mortar.

G. Provide expansion joints where shown. Conform to details shown.

H. Flashing:

1. Clean surface of masonry smooth and free from projections which might puncture or otherwise damage flashing.
2. Install in accordance with manufacturer's recommendations to provide continuous flashing system.
3. Provide end dam at each end of flashing to funnel flow out of wall.
4. Turn up sheet flashing a minimum of 8 inches and fully adhere to substrate.
5. Fully adhere sheet flashing to top of metal drip edge and cut off sheet flashing 1/2 inch back from exterior face.
6. In cold or wet weather when flashing will not fully adhere to substrate, provide termination bar mechanically anchored to substrate at top of flashing to secure flashing in place.

I. Provide weepholes by vents at base of flashings. Space not over 32 inches on center with a minimum of 1 weephole between openings. Keep weepholes and area above flashings free of mortar.

J. Build into masonry rough frames, metal frames, lintels, anchors, anchor bolts, inserts, sleeves, brackets, etc.

K. Install insulation into cavities of exterior walls. Conform to requirements of Section 07 21 00.

L. Tolerances: Conform to requirements of ACI 530.1.

3.03 PROTECTION

A. Protect masonry from damage.

B. Cover freshly laid masonry and walls not being worked on to prevent rapid drying and to exclude rain and snow.

3.04 CLEANING

A. Clean as units are set and daily.

B. Remove surplus mortar and leave surface clean and finished.

C. Upon completion, visually inspect Work and point, or cut out and repoint all holes and defective joints.

D. Thoroughly clean all brick surfaces to be left exposed in finished work. Use brick cleaner in accordance with manufacturer's recommendations. Acid shall not be used.

END OF SECTION

SECTION 04 22 00
CONCRETE UNIT MASONRY

PART 1 – GENERAL

1.01 SUMMARY

A. Provide concrete unit masonry where shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

1.02 REFERENCES

A. ASTM: American Society for Testing and Materials

B. ACI: American Concrete Institute

1.03 SUBMITTALS

A. Shop Drawings:

1. Source, material certificates, and proportions by weight of cement, fine and coarse aggregates, and admixtures for mortar and masonry grout.
2. Bar reinforcement shop drawings.

B. Product Data:

1. Wall reinforcing and anchors manufacturer's literature.
2. Weephole manufacturer's literature.

C. Test Results:

1. Mortar test results.

D. Miscellaneous Submittals:

1. Material certification for masonry units. Test data shall not be more than 3 year old.

E. American Iron and Steel Compliance Certification:

1. This project is being funded by the Clean Water State Revolving Fund that requires that all of the iron and steel products used in the project to be produced in the United States ("American Iron and Steel Requirement"). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R. 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.
2. The Manufacturer shall provide with the shop drawing submittal one signed and dated Certification Letter (a sample copies of which are provided in the Appendix). The Certification Letter shall demonstrate compliance with Section 436 of federal H.R. 3547.

F. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Testing:

1. Testing shall be provided by Contractor in accordance with Section 01 45 29 and this section.
2. Before construction starts, tests shall be made on laboratory prepared mortar using job materials and proportions. Results shall conform to ASTM C270.
3. Before construction starts, test job-mixed mortar in accordance with ASTM C780 and correlate results with laboratory prepared mortar. Perform consistency, water-content, air-content, and compressive strength tests.
4. During construction, test mortar weekly in accordance with ASTM C780.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store masonry units above ground on level platforms which allow air circulation under the stacked units.

B. Cover and protect against wetting prior to use.

C. Deliver decorative units packaged in manner to prevent damage.

1.06 PROJECT / SITE CONDITIONS

A. Cold Weather Protection:

1. Temperature of masonry units shall not be less than 32°F when laid.
2. When air temperature falls below 40°F or when temperature of masonry units is below 40°F:

a. Remove visible ice on masonry units before unit is laid.
b. Heat mortar sand or mixing water to produce mortar temperature between 40°F and 120°F.
c. When air temperature is between 25°F and 40°F, completely cover masonry by covering with weather resistant membrane for 24 hours after construction.
d. When air temperature is between 20°F and 25°F, use heat sources, install wind breaks when wind velocity exceeds 15 miles per hour, and completely cover masonry with insulating blankets for 24 hours after construction.
e. When air temperature is below 20°F, provide enclosure and use heat source to maintain temperature within enclosure above 32°F for 24 hours after construction.

B. Hot Weather Protection:

1. When air temperature exceeds 100°F, or 90°F with wind velocity greater than 8 miles per hour:

a. Do not spread mortar more than 4 feet ahead of masonry.
b. Set units within 1 minute of spreading mortar.

PART 2 – PRODUCTS

2.01 MORTAR AND GROUT

A. Materials:

1. Portland Cement: ASTM C150, Type I.
2. Masonry Cement: ASTM C91, Type S.
3. Lime: Hydrated lime, ASTM C207, Type S.
4. Aggregates:

a. Mortar: ASTM C144, acceptable in color, 10% passing No. 100 sieve.
b. Masonry Grout: ASTM C404.

5. Water: Potable.
6. Coloring Pigments: Commercial iron oxide, manganese dioxide, or chromium oxide of color selected by Engineer.
7. Do not use antifreeze compounds.

B. Proportions:

1. Mortar: ASTM C270, property specification Type S (1800 pounds per square inch).
2. Masonry Grout: ASTM C476 (2500 pounds per square inch minimum).
3. Use water repellant admixture in mortar for units exposed to earth or weather in accordance with manufacturer's written recommendations. Do not use water repellant admixture for brick masonry.

2.02 CONCRETE MASONRY UNITS

A. Hollow Lightweight Concrete Block: ASTM C90.

B. Hollow Normal Weight Concrete Block: ASTM C90.

C. Solid Block: ASTM C90, normal weight.

D. Provide fire rated units where noted.

E. Provide special block for corners, control joints, jambs, sills, lintels, bond beams, etc. Joints at outside corners are not acceptable.

F. Provide bull nose edges where shown and at all interior exposed vertical corners, including door and window openings.

G. Block shall be manufactured with water repellant admixture.

2.03 REINFORCEMENT AND ANCHORS

A. Horizontal Joint Reinforcement:

1. Truss-Mesh, Ladder-Mesh, Ladder-Tri-Mesh, Ladder-Box-Mesh, Truss-Box-Mesh, Adjustable Ladder, Adjustable Truss by Hohmann & Barnard, Inc.
2. 2 or 3 longitudinal 9 gauge galvanized rods welded to 9 gauge cross rods at 16 inches on center, conforming to ASTM A82.
3. Provide special manufactured corner and wall intersection pieces.
4. Zinc coated.

a. Interior walls: ASTM A641, Class I.
b. Exterior walls: ASTM A153, Class B2.

B. Reinforcing Bars: Conform to requirements of Section 03 20 00.

C. Dovetail Anchor Slots and Anchors:

1. 20 gauge galvanized dovetail foam filled anchor slots compatible with anchors.
2. 16 gauge by 1 inch galvanized corrugated, dovetailed metal anchor straps. Where heavy duty anchors are called for, provide 3/16 inch thick anchor straps.
3. Zinc coated in accordance with ASTM A153, Class B2.

2.04 MORTAR CATCHER

A. Manufacturers:

1. Mortar Trap by Hohmann & Barnard, Inc.
2. MortarNet by Mortar Net Solutions.

B. Mesh material placed in the wall cavity to prevent mortar droppings from blocking weep holes.

2.05 FLASHING

A. Conform to the requirements of Section 04 21 13.

2.06 EXTERIOR MASONRY SEALER

A. Manufacturers:

1. Chemstop WB Heavy Duty by Euclid Chemical Co.
2. Infiniseal DB by W.R. Grace & Co.

B. Exterior breathable sealer compatible with water repellant admixture.

PART 3 – EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 CONCRETE MASONRY UNITS

A. General:

1. Use lightweight block or normal weight block for interior partitions or backing for exterior walls.
2. Use normal weight block with water repellant admixture where exposed to earth or weather.
3. Lay only dry masonry units.
4. Use masonry saws to cut and fit masonry units.
5. Set units plumb, true to line, and with level courses accurately spaced.
6. Clean the top surface of foundation free from dirt and debris prior to start of installing first course.
7. Accurately fit the units to plumbing, ducts, openings, and other interfaces, neatly patching all holes.
8. Keep the walls continually clean, preventing grout and mortar stains. If grout does run over, clean immediately.

B. Unless otherwise shown on the Drawings, provide running bond with vertical joints located at center of masonry units in the alternate course below. Acoustic block shall be laid stack bond.

C. Do not use chipped or broken units. If such units are discovered in the finished wall, Engineer may require their removal and replacement with new units at no additional cost to the Owner.

D. Laying up:

1. Place units in mortar with full bed and head joints where cells are to be filled with mortar or masonry grout. Other masonry shall have face-shell bedding.
2. Align vertical cells of hollow units to maintain a clear and unobstructed system of flues.
3. Reinforce walls with continuous horizontal joint reinforcement spaced at 16 inches on center. Reinforce parapets with continuous horizontal joint reinforcement spaced at 8 inches on center. Lap reinforcement minimum of 8 inches, and stagger laps minimum of 32 inches.
4. Bond intersections of walls with horizontal joint reinforcement, conform to details shown.
5. Tie / reinforce cavity walls with horizontal joint reinforcement.
6. Where block laid against cast-in-place or precast concrete, provide vertical dovetail anchor slots at 2 feet on center with dovetail anchors at 16 inches on center.

E. Bar Reinforcement:

1. Provide reinforcement as shown on the Drawings.
2. Provide required metal accessories to ensure adequate alignment of steel during grout filling operations.
3. Unless otherwise shown, provide continuous bond beam around top of buildings at roof bearing elevation. Reinforce with 2 No. 5 bars.

F. Tooling:

1. Tool joints to a dense, smooth surface.
2. Unless otherwise shown on the Drawings, provide joints of "concave" pattern throughout.
3. Brush with soft brush to remove projecting mortar.
4. Cut mortar flush with surface on concealed surfaces.

G. Provide control joints where shown. Conform to details shown.

H. Provide reinforced masonry lintels over openings where noted and where steel lintels not provided. Form lintels by using bond beam units to match wall texture. Lintels shall bear on masonry minimum 8 inches beyond each side of opening. Openings 4 feet and less in width, that do not have a lintel scheduled, shall have 8 inch high reinforced masonry lintels reinforced with 2 No. 5 bars, double steel angle lintels or W8 beam with ledge angle lintels per details on drawings. Steel lintels shall conform to requirements of Section 05 50 00.

I. Flashing:

1. Conform to the requirements of Section 04 21 13.

J. Build into masonry rough frames, metal frames, lintels, anchors, anchor bolts, inserts, sleeves, brackets, bearing plates, etc.

K. Install insulation into cells of exterior walls. Conform to requirements of Section 07 21 19.

L. Tolerances: Conform to requirements of ACI 530.1.

3.03 GROUTING

A. Perform grouting in strict accordance with the provisions of ACI 530.1.

1. Spaces to be grouted shall be free of mortar droppings, debris, and loose aggregate.
2. Provide cleanouts at the bottom of each cell containing vertical reinforcement when pour height exceeds 4 feet.

3. Solidly fill vertical cells containing reinforcement with masonry grout.
4. Fill cores under lintels with masonry grout.
5. Consolidate grout at time of pour by puddling with a mechanical vibrator, filling all cells of the masonry, and then reconsolidating later by puddling before the plasticity is lost.

3.04 PROTECTION

A. Protect masonry from damage.

B. Cover freshly laid masonry and walls not being worked on to prevent rapid drying and to exclude rain and snow.

C. Brace walls until roof or floor system in-place.

D. Do not apply superimposed loads until completed masonry reaches design strength.

3.05 CLEANING

A. Clean as units are set, daily, and upon completion. Acid shall not be used.

B. Remove surplus mortar and leave surface clean and finished.

END OF SECTION

SECTION 04 73 23
CALCIUM SILICATE MASONRY UNITS

PART 1 – GENERAL

1.01 SUMMARY

A. Calcium silicate manufactured stone masonry units, and other features as shown on Drawings.

1.02 REFERENCES

A. ASTM: American Society for Testing and Materials

1.03 SUBMITTALS

A. Shop Drawings:

1. Cutting and setting drawings showing sizes, dimensions, sections, and profiles of cast stone units, arrangement and provisions for jointing, anchoring and fastening, supports, and other necessary details.

a. Show location of inserts to be built into concrete or masonry.
b. Show large-scale details of decorative surfaces and inscriptions.

B. Product Data:

1. Specifications and other data for each type of accessory required.
2. Instructions for handling, storage, installation, and protection of cast stone.

C. Samples:

1. 2 samples not less than 12-inches by 12-inches, in size of each different color, grade, and finish of stonework required. Include full range of exposed color and texture to be expected in completed Work.

D. Sample Panel:

1. 6 feet long by 4 feet high panel showing:

a. Face brick, calcium silicate masonry units (rock and smooth face) and CMU units.
b. Color range.
c. Texture range.
e. Bonding.
d. Mortar color.
e. Tooled joints.
f. Quality of workmanship.

2. Do not start Work until Engineer has accepted sample panel.
3. Use panel as standard of comparison. Failure of masonry work to meet or exceed quality of work depicted by sample panel shall be cause for rejection.
4. Do not destroy or move panel until Work completed and accepted by Owner.
5. When approved by Engineer, sample panel may be incorporated into finished work.

E. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Source Quality Control:

1. Manufacturer Qualifications: Manufacturer having sufficient plant facilities to produce the shapes, quantities and size of products required in accordance with the project documents.

1.05 DEVLIVERY, STORAGE, AND HANDLING

A. Protect calcium silicate masonry units during storage and construction against moisture, soiling, staining, and physical damage.

B. Handle calcium silicate masonry units to prevent chipping, breakage, soiling or other damage. Do not use pinch or wrecking bars without protecting edges of units with wood or other rigid materials. Lift with wide belt type slings where possible; do not use wire rope or ropes containing tar or other substances which might cause staining. If required, use wood rollers and provide cushion at end of wood slides.

C. Store calcium silicate masonry units on wood skids or pallets, covered with non-staining, water-proof membrane. Place and stack skids and units to distribute weight evenly and to prevent breakage or cracking of stones. Protect stored units from weather with waterproof, non-staining covers or enclosures, but allow air to circulate around stones.

D. Protect mortar materials and stonework accessories from weather, moisture, and contamination with earth and other foreign materials.

1.06 PROJECT / SITE CONDITIONS

A. Cold Weather Protection:

1. Conform to requirements of Section 04 22 00.

B. Hot Weather Protection:

1. Conform to requirements of Section 04 22 00.

1.07 AMERICAN IRON AND STEEL

A. This project is being funded with monies made available by the Safe Drinking Water Loan Program that has statutory requirements commonly known as “American Iron and Steel;” that requires that all of the iron and steel products used in the project to be produced in the United States (“American Iron and Steel Requirement”). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.

B. The Manufacturer shall provide with the shop drawing submittal one signed and dated original of the fully completed Certification Letter (a sample copy of which is provided in the Appendix of this manual). Said form shall demonstrate compliance with Section 436 of federal H.R. 3547. Submit in accordance with Section 01 33 00.

PART 2 – PRODUCTS

2.01 CALCIUM SILICATE MASONRY UNITS

A. Furnish calcium silicate masonry units complying with ASTM C73, Grade SW, that have been pressure formed and autoclaved: 3-5/8 in. bed depth, special shapes as indicated and as follows:

1. Modular size: 3-5/8 in. wide by 3-5/8 in. high by 23-5/8 in. long as indicated on drawings.
2. Texture: Rocked finish on exposed faces and ends.
3. Color: As selected by ENGINEER from manufacturer's color range.
4. Calcium silicate masonry units shall be Renaissance Masonry Units by Arriscraft or approved equal.

B. Furnish calcium silicate masonry units complying with ASTM C73, Grade SW, that have been pressure formed and autoclaved: 3-5/8 in. bed depth, special shapes as indicated and as follows:

1. Modular size: 3-5/8 in. wide by 7-5/8 in. high by 23-5/8 in. long as indicated on drawings.
2. Texture: Smooth finish on exposed faces and ends.
3. Color: As selected by ENGINEER from manufacturer's color range.
4. Calcium silicate masonry units shall be Renaissance Masonry Units by Arriscraft or approved equal.

2.02 MORTAR

A. A. Cement:

1. Portland Cement: White ASTM C150, except complying with staining requirements of ASTM C91 for not more than 0.03% water soluble alkali. Furnish Type I, except Type III may be used for setting stonework in cold weather.
2. Masonry Cement: ASTM C91, nonstaining.

B. Hydrated Lime: ASTM C207, Type S.

C. Sand: ASTM C144, except graded with 100% passing No. 16 sieve.

1. For white or colored pointing mortar, furnish natural white sand or ground white stone meeting specified requirements.

D. Water: Potable.

E. Mortar: Nonstaining, cement/lime mortar, complying with ASTM C270, Type N proportion specification, using specified materials. Color as selected by Engineer.

2.03 STONEWORK ACCESSORIES

A. Expansion Anchors: 316 stainless steel, type and size shown or, if not shown, as required to support loading involved.

B. Anchor Bolts, Nuts, and Washers: 316 stainless steel.

C. Stone Anchors: 316 stainless steel, type and size indicated or, if not indicated, as required to securely anchor and fasten stonework in-place.

D. Setting Buttons: Lead or plastic buttons of thickness required for joint size indicated, and of size required to maintain uniform joint width.

2.04 FABRICATION

A. General: Fabricate as shown and detailed on Shop Drawings and in compliance with recommendations of applicable calcium silicate masonry units manufacturer. Provide holes and

sinkages cut or drilled for anchors, fasteners, supports, and lifting devices, as shown and necessary to secure units in-place. Cut and backcheck as required for proper fit and clearance. Shape beds to fit supports.

B. Cut accurately to shape and dimensions shown on Shop Drawings, maintaining fabrication tolerances of applicable calcium silicate masonry unit manufacturer.

1. Dress joints (bed and vertical) straight and at 90-degree angle to face, unless otherwise indicated.
2. Provide quirk-mitered corners, unless otherwise shown.
3. Joint Width: Cut to provide joint widths as indicated or, if not indicated, cut to allow for uniform 3/8 inch wide joints.

PART 3 – EXECUTION

3.01 PREPARATION

A. Advise installers of other Work about specific requirements relating to placement of inserts and flashing reglets to be used by stone mason for anchoring and supporting and flashing of stonework. Furnish installers of other work with drawings or templates showing location of inserts for stone anchors and supports.

B. Clean stone before setting by thoroughly scrubbing with fiber brushes followed by thorough drenching with clear water. Use only mild cleaning compounds containing no caustic or harsh fillers or abrasives. If not thoroughly wet at time of setting, drench or sponge stone. Do not wet expansion or control joint surfaces.

3.02 INSTALLATION

A. Execute calcium silicate masonry units by skilled mechanics and employ skilled fitters at site to do necessary field cutting as units are set.

B. Where calcium silicate masonry units will contact ferrous metal surfaces concealed in back-up construction (anchors, supports, structural framing, and similar surfaces), apply heavy coat of bituminous paint on metal surfaces prior to setting of stone. Do not extend coating onto portions of ferrous metal exposed in finished Work. Do not apply coating to stainless or nonferrous metals.

C. Provide expansion joints where shown. Do not fill with mortar. Install continuous strips of preformed joint filler to allow for installation of backer rod and sealant, as specified in Section 07 92 00.

D. Set calcium silicate masonry units in accordance with Drawings and Shop Drawings. Provide anchors, supports, fasteners, and other attachments shown or necessary to secure units in-place. Shim and adjust accessories for proper setting of units. Completely fill holes, slots, and other sinkages for anchors, dowels, fasteners, and supports with mortar during setting of units.

E. Allowable Tolerances:

1. Variation from Plumb: For lines and surfaces of columns, walls and arises, do not exceed 1/4 inch in 10 feet, 3/8 inch in story height or 20 feet maximum, nor 1/2 inch in 40 feet or more. For external corners, expansion joints, and other conspicuous lines, do not exceed 1/4 inch in any story or 20 feet maximum, nor 1/2 inch in 40 feet or more.
2. Variation from Level: For grades shown for exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines, do not exceed 1/4 inch in any bay or 20 feet maximum, nor 3/4 inch in 40 feet or more.

3. Variation of Linear Building Line: For position shown in plan and related portion of columns, walls, and partitions, do not exceed 1/2 inch in any bay or 20 feet maximum, nor 3/4 inch in 40 feet or more.
4. Variation in Cross-sectional Dimensions: For columns and thickness of walls from dimensions shown, do not exceed -1/4 inch nor +1/2 inch.

F. Cavity Construction: Where open space between back of stone units and back-up or framing is shown, keep cavity open; do not fill with mortar or grout.

G. Joints

1. Butter vertical joints full width before setting and set units in full bed of mortar, unless otherwise indicated.
2. Rake out joints before mortar is set to allow for sealant pointing as shown. See Section 07 92 00 for backer rod and sealant.
3. Head joints in coping shall be left open and sealed. See Section 07 92 00 for backer rod and sealant.
4. Tool slightly concave.

H. Bond:

1. As indicated on Drawings.
2. Calcium silicate lengths shall minimum 1 ft-6 in. and maximum 4 ft-0 in.

3.03 FIELD QUALITY CONTROL

A. Remove and replace calcium silicate masonry units which are broken, chipped, stained or otherwise damaged. Remove and replace units which do not match adjoining stonework. Provide new matching units, install as specified, and point-up joints to eliminate evidence of replacement. Repoint defective and unsatisfactory joints as required to provide neat, uniform appearance.

3.04 CLEANING

A. Clean calcium silicate masonry units not less than 6 days after completion of Work. Use clean water and stiff-bristle brushes. Do not use wire brushes, acid type cleaning agents or other cleaning compounds with caustic or harsh fillers.

3.05 PROTECTION

A. Provide final protection and maintain conditions in manner acceptable to fabricator and installer which ensures calcium silicate masonry units being without damage, discolorations or deterioration during subsequent construction and until Substantial Completion.

END OF SECTION

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DIVISION 05

METALS

SECTION 05 50 00
METAL FABRICATIONS

PART 1 – GENERAL

1.01 SUMMARY

A. Provide miscellaneous metal work shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

B. Section Includes:

1. Concrete anchors.
2. Stairs.
3. Ladders.
4. Grating support angles and framing.
5. Weirs and scum baffles.
6. Lintels.
7. Metal frames.
8. Floor access hatches.
9. Safety grate.
10. Roof access hatches.
11. Stair Nosings.
12. Miscellaneous items.

1.02 DEFINITIONS

A. Submerged: At or below level 1 foot 6 inches above maximum water level in water holding structures.

1.03 REFERENCES

A. AISC: American Institute of Steel Construction

B. AA: Aluminum Association

C. AWS: American Welding Society

D. ASTM: American Society for Testing and Materials

E. AISI: American Iron and Steel Institute

F. OSHA: Occupational Safety and Health Administration

1.04 SUBMITTALS

A. Shop Drawings:

1. Indicate materials, sizes, connections, anchors, and finishes.

B. Product Data:

1. Manufacturer’s catalog sheets on premanufactured items.

C. Miscellaneous Submittals:

1. Floor and roof access hatch warranty.

D. Submit in accordance with Section 01 33 00.

1.05 QUALITY ASSURANCE

A. Perform shop and/or field welding required in connection with the work of this Section by certified welders in strict accordance with pertinent recommendations of AWS.

B. Conform to AISC and AA standards.

1.06 AMERICAN IRON AND STEEL

A. This project is being funded with monies made available by the Safe Drinking Water Loan Program that has statutory requirements commonly known as “American Iron and Steel;” that requires that all of the iron and steel products used in the project to be produced in the United States (“American Iron and Steel Requirement”). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.

B. The Manufacturer shall provide with the shop drawing submittal one signed and dated original of the fully completed Certification Letter (a sample copy of which is provided in the Appendix of this manual). Said form shall demonstrate compliance with Section 436 of federal H.R. 3547. Submit in accordance with Section 01 33 00.

PART 2 – PRODUCTS

2.01 MATERIALS

A. In fabricating items which will be exposed to view, limit materials to those which are free from surface blemishes, pitting, and roughness.

B. Comply with following standards, as pertinent.

1. Structural Steel Shapes:

a. W Shapes:	ASTM A992, 50 ksi.
b. M Shapes:	ASTM A36.
c. S, C and MC Shapes:	ASTM A36.
d. L Shapes:	ASTM A36.
e. HP Shapes:	ASTM A572 Grade 50.
f. HSS Square and Rectangular Shapes:	ASTM A500, Grade B, 46 ksi.
g. HSS Round Shapes:	ASTM A500, Grade B, 42 ksi
h. Pipe Shapes:	ASTM A53, Grade B, 35 ksi.
i. Plates and Bars:	ASTM A36.

2. Stainless Steel:

a. Exterior and submerged uses: AISI, Type 316.
b. Interior uses: AISI, Type 304 or Type 316.

3. Aluminum shapes and plates: Alloy 6061-T6 or 6063-T6.
4. Floor Plate: Checkered surface aluminum plate.
5. Connection Bolts:

a. For steel members: ASTM F3125 Grade A325.
b. For wood members: ASTM A307, galvanized.
c. For aluminum and galvanized steel members: Stainless steel.

6. Cast-in-place Anchor Bolts:

a. 1/2 inch minimum diameter.
b. Nonsubmerged: ASTM A307, galvanized.
c. Submerged: Stainless steel.

7. Malleable Iron: ASTM A47.
8. Cast Iron: ASTM A48, Class 35B.
9. Ductile Iron: ASTM A536, Grade 65-45-12.
10. Cast Aluminum: ASTM B26.

2.02 CONCRETE ANCHORS

A. Wedge Anchors:

1. Manufacturers:

a. Power-Stud+ SD1, SD2, SD4 or SD6 by Dewalt.
b. Kwik Bolt TZ by Hilti Corp.
c. Ankr-TITE Wedge Anchor by Wej-it Fastening Systems.
d. Strong-Bolt 2 by Simpson Strong-Tie Co., Inc.

2. Usage: In concrete.

a. 316 stainless steel unless noted otherwise.
b. Do not use when submerged or subjected to dynamic loads.

B. Expansion Anchors:

1. Manufacturers:

a. Power-Bolt+ by Dewalt.
b. HSL-3 by Hilti Corp.

2. Usage: In concrete.

a. 316 stainless steel unless noted otherwise.
b. Do not use when submerged, in overhead applications, or subjected to dynamic loads.

C. Sleeve Anchors:

1. Manufacturers:

a. Lok-Bolt AS by Dewalt.
b. HLC by Hilti Corp.
c. Sleeve-TITE Sleeve Anchors by Wej-it Fastening Systems.
d. Sleeve-All by Simpson Strong-Tie Co., Inc.
e. Dynabolt by Red Head.

2. Usage: In masonry.

a. Stainless steel.

D. Undercut Anchors:

1. Manufacturers:

a. Atomic+ Undercut by Dewalt.
b. HDA by Hilti Corp.
c. Maxi-Bolt by Drillco Devices Ltd.
d. Torq-Cut by Simpson Strong-Tie Co., Inc.

2. Usage: In concrete, overhead applications, and for dynamic loads.

a. 316 stainless steel.
b. Do not use when submerged.

E. Adhesive Anchors (Concrete):

1. Manufacturers:

a. HIT RE 500-V3 or HIT-HY 200 Adhesive Anchor by Hilti Corp.
b. Pure 110+ or AC200+ by Dewalt.
c. SET-3G, SET-XP or AT-XP Adhesive System by Simpson Strong-Tie Co., Inc.
d. A7+, G5+ or C6+ by Red Head.

2. Adhesive with 316 stainless steel stud assembly.
3. Usage:

a. In concrete, submerged.
b. Do not use in overhead applications.

F. Adhesive Anchors (Masonry):

1. Manufacturers:

a. HIT-HY 270 Adhesive Anchor by Hilti Corp.
b. AC100+ Gold by Dewalt.
c. SET-XP Adhesive System by Simpson Strong-Tie Co., Inc.
d. A7+ or C6+ by Red Head.

2. Adhesive with 316 stainless steel stud assembly.
3. Usage:

a. In masonry.
b. Grout masonry cores at anchor locations unless noted otherwise or approved by Engineer.
c. Provide screen tube inserts for hollow masonry units or multi-wythe masonry.
d. Do not locate anchors in vertical mortar joints.

G. Screw Anchors:

1. Manufacturers:

a. Wedge-Bolt or Screw-Bolt+ by Dewalt.
b. Kwik-Con II+ or Kwik HUS by Hilti Corp.

c. Titen or Titen HD by Simpson Strong-Tie Co., Inc.
d. Tapcon or Large Diameter Tapcon (LDT) by Red Head.

2. Zinc plated carbon steel or stainless steel concrete/masonry screw with hex head.
3. Usage:

a. In concrete, where noted or approved by Engineer.
b. In masonry, where noted or approved by Engineer.

H. Hollow Core Plank Anchors:

1. Manufacturers:

a. Hollow-Set Dropin or Mini Dropin by Dewalt.
b. Hollo Set Drop-In Anchor by Wej-it Fastening Systems.
c. Hollow Drop-In Anchor by Simpson Strong-Tie Co., Inc.
d. Multi-Set II RX by Red Head.
e. HDI-P by Hilti Corp.

2. Usage: In precast concrete hollow core plank.

a. Zinc plated carbon steel or stainless steel.
b. Overhead applications in interior locations for attachment of light duty pipe and equipment supports.
c. Do not use in corrosive or humid areas, tanks, when submerged, or subjected to dynamic loads.
d. For heavy duty pipe and equipment supports or when subject to dynamic loads, use anchors that completely penetrate the plank.

I. Rod Hanger Anchors:

1. Manufacturers:

a. Hangermate+ or Snake+ by Dewalt.
b. KH-EZ I by Hilti Corp.
c. Titen HD by Simpson Strong-Tie Co., Inc.
d. Hang-TITE Rod Hanger Screw by Wej-it Fastening Systems.

2. Usage: In concrete.

a. Zinc plated carbon steel or stainless steel unless noted otherwise.
b. Overhead applications in interior locations for attachment of light duty pipe and equipment supports.
c. Do not use in corrosive or humid areas, tanks, when submerged, or subjected to dynamic loads.

2.03 FINISHES

A. Primer: Conform to requirements of Section 09 96 00.

B. Galvanizing Repair Paint: High zinc-dust content paint complying with MIL-P-21035.

2.04 FABRICATION

A. Except as otherwise shown on the Drawings or the approved Shop Drawings, use materials of size, thickness, and type required to produce reasonable strength and durability in the work of this Section.

B. Provide clips, lugs, brackets, straps, plates, bolts, nuts, washers, and similar items, as required for fabrication and erection.

C. Fabricate with accurate angles and surfaces which are true to the required lines and levels, with projecting corners clipped, grinding exposed welds smooth and flush, forming exposed connections with hairline joints, and using concealed fasteners wherever possible.

D. Weld shop connections and bolt or weld field connections.

E. Use AISC standard 2-angle web connections or single plate framing connections capable of supporting min of 50% of total uniform load capacity of member.

F. Connections shall consist of minimum two 3/4 inch diameter bolts or welds developing minimum of 10,000 pounds capacity.

G. Prior to shop painting or priming, properly clean metal surfaces as required for the applied finish and for the proposed use of the item. Conform to Section 09 96 00.

1. Do not coat ferrous metal surfaces embedded in concrete.
2. Coating of cast iron or ductile iron floor access hatches and pressure relief valves not required.
3. On surfaces inaccessible after assembly or erection, apply two coats of the specified primer. Change color of second coat to distinguish it from the first.
4. Coat aluminum surfaces in contact with concrete in accordance with AA and Section 09 96 00. Under no circumstances shall aluminum contact dissimilar metal.

H. Galvanizing:

1. Galvanize after fabrication.
2. Galvanize by hot-dip process conforming to ASTM A123 and AHDGA specifications.

2.05 STAIRS

A. Construct stairs and platforms of aluminum channel stringers and framing members to support uniform live load of 100 pounds per square foot or a moving concentrated load of 1000 pounds, whichever produces the greatest stress.

B. Close exposed ends of stringers with plates, continuously welded to main member.

C. Provide grating treads and landing platforms. Conform to Section 05 53 13.

2.06 LADDERS

A. Ladders shall conform to OSHA and local building code safety requirements.

B. Construct from aluminum, 6063-T5 or 6060-T6 alloy, mill finish

1. Stringers: 1-1/2 inch diameter schedule 40 pipe (nominal 2 inch outside diameter.), minimum clear spacing 18 inches.
2. Rungs: 2 inch serrated C-channel.
3. Other materials shall be minimum ¼ inch thick.

4. Weld rungs to stringers.
5. Fabricate brackets for fastening ladders to wall, weld to ladder.

C. Safety Devices:

1. Unless otherwise noted, equip ladders over 10 feet tall with aluminum safety climbing devices as manufactured by TS Group.

a. Safety rail shall be TS Safety Rail.
b. 2 TS Trolleys at each ladder.
c. 10 TS safety belts. Verify size with Owner.
d. 1 TS ice guard for each exterior ladder.
e. TS removable extension safety rail extensions on ladders accessible from top. Where permanent installation not possible, provide removable extension. Position extension on brackets near top of ladder so climber can readily install extension.

2. Safety rail climbing devices shall allow worker to operate freely in normal climbing position during ascent or descent. Device shall enable worker to be attached to device during climb without having to remove hands from ladder to operate system effectively, and be able to easily pivot onto and off work platforms or landings while safely attached to device.

D. Retractable Safety Post:

1. Provide safety post extension at top of ladder where noted. Device shall be aluminum. It shall be designed with telescoping tubular section that locks automatically when extended. Movement shall be controlled by stainless steel spring mechanism. Device shall be secured to ladder rungs.

a. Ladder UP by Bilco.
b. Ladder Safety Post by Nystrom.

2.07 GRATING SUPPORT ANGLES AND FRAMING

A. Provide aluminum support angles embedded in concrete, unless noted otherwise. Angles shall be 1/4 inch thick, inside depth shall equal depth of grating, inside length shall equal depth of grating, but not less than 1-1/4 inch. Provide 1 inch by 1/4 inch by 8 inches long strap anchors or 3/8 inch diameter by 6 inches long headed anchor studs welded to back of angles at 18 inches on center.

B. Provide aluminum angles, channels, and beams as noted bolted to concrete or masonry with concrete anchors as noted.

2.08 WEIRS AND SCUM BAFFLES

A. Straightedge Weir Plates:

1. 1/4 inch stainless steel plates and angles.
2. Stainless steel bolts, nuts, washers, and concrete anchors.
3. Provide in lengths to suit tank, but not to exceed 12 feet.
4. Grind top edges smooth.
5. Conform to details shown.

2.09 LINTELS

A. Provide steel lintels over openings in masonry walls as noted and wherever reinforced masonry or concrete lintels are not provided.

B. Fabricate lintels from structural steel shapes as detailed, selected for straightness of section, with minimum of 8 inches bearing each side of opening. Hot-dip galvanize lintels after fabrication.

C. Openings 4 feet and less in width without lintel scheduled, shall have steel lintel L-1 or reinforced masonry lintels. Total width of horizontal legs shall be 1 inch less than nominal thickness of wall. Weld angles together. Masonry lintels shall conform to requirements of Section 04 22 00.

2.10 METAL FRAMES

A. Provide door, hatch, grille, louver, and other frames fabricated from structural shapes or plates.

B. Select sections for trueness of web and flange. Straighten members so finished frames are uniform, square, and true throughout length and depth of assembled units.

C. Miter or cope and join members with continuous welds.

D. Provide temporary spreader bars to prevent springing frames out of shape prior to and during erection.

2.11 FLOOR ACCESS HATCHES

A. Prefabricated Drainage Channel Type:

1. Manufacturers:

   a. Bilco Type J or JD.
   b. Halliday Type W1S or W2S.
   c. Nystrom FDDP Series.

2. Provide access hatches and frames of material, type, and size as shown on Drawings.
3. Door leaves shall be 1/4 inch minimum diamond pattern plate with reinforcing on underside to withstand live load of 300 pounds per square foot with max deflection of 1/150 span.
4. Frames shall be 1/4 inch minimum thick channel to allow for adequate water drainage with anchor flange around perimeter.
5. Equip hatches with heavy stainless steel hinges with 3/8 inch minimum stainless steel pins bolted to underside and pivot so cover does not protrude into channel frame.
6. Provide compression spring operators enclosed in telescoping tubes for smooth, easy and controlled door operation.
7. Equip hatches with hold-open arm with positive locking device with conveniently positioned release handle for easy and controlled closing.
8. Provide 316 stainless steel snap lock mounted on underside of leaf with removable topside handle and socket recessed in cover.
9. Provide drainage channel coupling.
10. Pipe drain to below.
11. Hardware shall be 316 stainless steel.
12. Factory finish on aluminum surfaces shall be mill finish with bituminous coating applied to surfaces in contact with concrete.
13. Manufacturer shall warranty in writing against defects in material and workmanship for 5 years.

2.12 SAFETY GRATE

A. Provide retractable safety grate across hatch openings, unless noted otherwise.

B. Net Type:

1. Manufacturers:

a. U. S. Netting Hatch Netting with Aluminum Rails
b. Nystrom Safety Net.

2. Aluminum and stainless steel construction with highly visible synthetic netting.
3. Rail mounted safety net system.
4. Netting shall be UV, industrial pollutant, and cleaning agent resistant.
5. Load rated to 300 pounds square per foot.

2.13 ROOF ACCESS HATCHES

A. Prefabricated Ladder Access:

1. Manufacturers:

a. Bilco Type S.
b. Nystrom RHP Series

2. Provide access hatches with integral curbs where noted.
3. Door leaves shall be 14 gauge stainless steel plate with neatly welded 3 inch beaded flange.
4. Curbs shall be 14 gauge stainless steel plate with 3½ inch flange for anchoring to roof deck.
5. Curbs shall be a minimum of 12 inches high above adjacent roofing.
6. Curbs shall be equipped with integral cap flashing matching curb material and thickness, welded at corners for watertightness.
7. Door leaves and curbs shall be insulated with 1 inch rigid glass fiber insulation. Insulation shall be covered with 18 gauge stainless steel plate. Hatch shall be constructed with a thermal break.
8. Equip hatches with heavy pintel hinges and compression springs in telescoping tubes.
9. Equip hatches with hold-open arm with positive locking device with conveniently positioned release handle for easy and controlled closing.
10. Provide snap lock mounted on underside of leaf with underside and topside handle.
11. All hardware shall be stainless steel.
12. Type 304 on stainless steel surfaces shall be mill finish with electrochemical passivation of welds and bituminous coating applied to surfaces in contact with concrete.
13. Manufacturer shall warranty in writing against defects in material and workmanship for 5 years.

B. Prefabricated Double Leaf Scuttle:

1. Manufacturers:

a. Bilco Type D.
b. Nystrom RHE-D Series.

2. Provide access hatches with integral curbs of the size noted.
3. Door leaves shall be 11 gauge aluminum plate with neatly welded 3 inch beaded flange.
4. Curbs shall be 14 gauge stainless steel plate extended 1 inch beyond concrete curb support with integral 2 inch apron.

5. Curbs shall be a minimum of 12 inches high above adjacent concrete curb.
6. Curbs shall be equipped with integral 14 gauge stainless steel cap flashing, welded at corners for watertightness.
7. Door leaves and curbs shall be insulated with 1 inch rigid glass fiber insulation. Insulation shall be covered with 14 gauge stainless steel plate.
8. Equip hatches with heavy pintel hinges and compression springs in telescoping tubes.
9. Equip hatches with hold-open arm with positive locking device with conveniently positioned release handle for easy and controlled closing.
10. Provide snap lock mounted on underside of leaf with underside and topside handle.
11. All hardware shall be stainless steel.
12. Type 304 on stainless steel surfaces shall be mill finish with electrochemical passivation of welds and bituminous coating applied to surfaces in contact with concrete.
13. Manufacturer shall warranty in writing against defects in material and workmanship for 5 years.

2.14 ROOFTOP TIE-BACK POST ANCHORS

A. Size: 14-inch high by 3-inch diameter standard stainless steel pipe with ¾-inch diameter stainless steel U-bar with stainless steel baseplate.

B. Working Load: 1,250 lb.

C. Ulitmate Load: 5,000 lb. in any direction.

D. Acceptable Manufacturer:

1. Axis Anchor Products
2. Miller Fusion Roof Anchor Post by Sperian
3. Or equal.

E. Locations: Provide rooftop anchors at locations shown on drawings.

2.15 STAIR NOSINGS

A. Manufacturers:

4. Wooster Products, Inc.: Supergrit Type 231BF.
5. American Safety Tread Co., Inc.: Type 3511.
6. Balco, Inc.: Type R-315P.
7. Safe T Metal Co., Inc.: Type BF131.

B. Nosings shall be exterior type aluminum safety treads; 3-inches wide by 1/4-inch thick, with 5 abrasive fitted ribs.

C. Provide aluminum stair nosings for setting in concrete for interior concrete stairs.

D. Nosings shall be 8-inches shorter than width of tread or landing.

2.16 MISCELLANEOUS ITEMS

A. Fabricate miscellaneous framing, supports, and items of structural shapes, plates, bars, and tubing of sizes and arrangements indicated and as required.

PART 3 – EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 INSTALLATION

A. General:

1. Set work accurately into position, plumb, level, true, and free from rack.
2. Tolerance: 1/8 inch in 10 feet.
3. Anchor firmly into position.
4. Where field welding is required, comply with AWS recommended procedures for appearance and quality of weld and for methods to be used in correcting welding work.
5. Grind exposed welds smooth, and touchup shop prime coats.
6. Do not cut, weld, or abrade surfaces which have been hot-dip galvanized after fabrication and which are intended for bolted or screwed field connections.
7. Perform cutting, drilling, and fitting as required for proper installation. Drill field holes for bolts, do not burn holes.
8. Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint the exposed areas with same material used for shop priming.

B. Concrete Anchors:

1. Do not install until concrete or masonry has reached its design strength.
2. Do not install closer than 6 bolt dia to edge of concrete or masonry, or closer than 12 bolt diameter to another anchor unless otherwise shown.
3. Minimum embedment shall be 8 bolt diameter.
4. Install in accordance with manufacturer's recommendations.

3.03 WEIRS, SCUM BAFFLES, AND SCUM BAFFLE SUPPORT BRACKETS

A. Install weirs, scum baffles, and supports in accordance with approved Shop Drawings.

B. Install to elevation indicated. Maintain top edges level and straight, with not more than 1/8 inch variation from level throughout entire length.

C. After installation complete, test weirs and scum baffles under normal operating conditions in presence of Engineer. Repair leaks and other imperfections found during testing.

3.04 ADJUSTING AND CLEANING

A. Clean exposed surfaces, removing dirt, dust, and other foreign matter.

B. Prepare surfaces for finished painting as specified is Section 09 96 00.

C. Field Repair of Damaged Galvanized Coatings:

1. Repair surfaces damaged during shipping, erection, or construction operations.
2. Use zinc rich paint.
3. Prepare surfaces and apply in accordance with ASTM A780, Annex A2.

END OF SECTION

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SECTION 05 52 00
METAL RAILING

PART 1 – GENERAL

1.01 SUMMARY

A. Provide aluminum handrail and railing as shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

1.02 REFERENCES

A. OSHA: Occupational Safety and Health Administration

1.03 SUBMITTALS

A. Shop Drawings:

1. Indicate materials, sizes, connections, anchors, and finishes.

B. Product Data:

1. Manufacturer's catalog sheets.

C. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Handrail and railing shall meet requirements of OSHA and local building code.

B. Provide end products of one manufacturer to achieve standardization of appearance.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle components in manner preventing damage to finished surfaces.

B. Pack units in individual plastic shrink-wrap to protect finish, do not remove until after installation.

C. Store in clean, dry condition away from uncured concrete and masonry. Cover with waterproof sheeting.

1.06 AMERICAN IRON AND STEEL

A. This project is being funded with monies made available by the Safe Drinking Water Loan Program that has statutory requirements commonly known as "American Iron and Steel;" that requires that all of the iron and steel products used in the project to be produced in the United States ("American Iron and Steel Requirement"). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.

B. The Manufacturer shall provide with the shop drawing submittal one signed and dated original of the fully completed Certification Letter (a sample copy of which is provided in the Appendix of this

manual). Said form shall demonstrate compliance with Section 436 of federal H.R. 3547. Submit in accordance with Section 01 33 00.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. BMC-Rail by Breuer Metal Craftsman, Inc.

B. ConnectoRail by Julius Blum Co., Inc.

C. Wesrail by Moultrie Manufacturing Co.

D. Series 500 by Superior Aluminum Products, Inc.

E. Or equal.

2.02 MATERIALS

A. Rails, Posts, and Formed Elbows: 1-1/2 inch diameter schedule 40 aluminum pipe (1.90 inch outside diameter, 0.145 inch wall thickness) alloy 6063-T6.

B. Fittings:

1. Riveted type fabricated from material similar to rails and posts.
2. Connections shall be continuous type to permit sliding of hands.
3. Fittings for open railing extensions shall be welded construction and welded to posts to comply with OSHA loading requirements. Welds shall be ground smooth and finished to match adjacent finish.
4. Base plates and side mounted flanges shall be aluminum or stainless steel.

C. Chain gates shall be 3/16 inch stainless steel link chain with stainless steel clasp capable of withstanding 250 pounds load.

D. Toe plate shall be 1/4 inch by 4 inches flat aluminum plate, alloy 6063-T6.

E. Mechanical fasteners shall be stainless steel.

2.03 FINISHES

A. Clear satin anodized finish:

1. Extruded Components: 0.7 mil.
2. Cast Components: 0.4 mil.

B. Light brushed finish on pipe and fittings before anodizing.

2.04 FABRICATION

A. Use materials of size, thickness, and type required to produce required strength and durability.

B. Fabricate with accurate angles and surfaces which are true to the required lines and levels, grinding welds smooth and flush, forming exposed connections with hairline joints, and using concealed fasteners wherever possible.

C. Form connections and changes in direction by using prefabricated fittings or radius bends.

D. Form elbow bends and wall returns to uniform radius, free from buckles and twists, with smooth finished surfaces.

E. Remove burrs from exposed cut edges.

F. Close pipe ends using prefabricated fittings.

G. Fabricate joints of exterior units to exclude water or provide weep holes where water may accumulate.

H. Provide base flange or side mounted base plate.

I. Coat surfaces to be in contact with concrete with bituminous paint.

PART 3 - EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 INSTALLATION

A. Assemble and install in accordance with manufacturer's written instructions.

B. Set posts plumb and align in each direction to within 1/8 inch in 10 feet maximum post spacing 5 feet on center.

C. Set rails horizontal or parallel to slope of surface or rake of steps to within 1/8 inch in 10 feet.

D. Provide expansion joints in rails and toe plate at 30 feet maximum on center. Locate within 12 inches of post.

E. Support handrail on brackets having 2 inch clearance between handrail and wall spaced not more than 5 feet on center and within 12 inches of each end of rail. Return handrail ends to within 1/2 inch of wall.

F. Locate chain gates as shown. Number of chains shall match number of horizontal rails. Chain drape shall not exceed 3 inches.

G. Provide toe plate except on stairs, where concrete curb provided and on top of walls that project above grade where foot traffic is not feasible.

H. Bolt to top of concrete or stair stringers. Bolt to side of platform framing.

3.03 CLEANING

A. Clean as recommended by railing manufacturer. Do not use acid, steel wool, or harsh abrasive.

B. If stains remain after cleaning, remove finish and restore in accordance with manufacturer's recommendations.

END OF SECTION

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SECTION 05 53 13
BAR GRATING

PART 1 – GENERAL

1.01 SUMMARY

A. Provide metal bar grating as shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

1.02 REFERENCES

A. NAAMM: National Association of Architectural Metal Manufacturers

1.03 SUBMITTALS

A. Shop Drawings:

1. Type, layout, dimensions, fasteners, welds, and locations.

B. Product Data:

1. Manufacturer's literature.

C. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Grating shall be end product of one manufacturer to achieve standardization of appearance.

B. Conform to Metal Bar Grating Manual and NAAMM requirements.

1.05 AMERICAN IRON AND STEEL

A. This project is being funded with monies made available by the Safe Drinking Water Loan Program that has statutory requirements commonly known as "American Iron and Steel;" that requires that all of the iron and steel products used in the project to be produced in the United States ("American Iron and Steel Requirement"). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.

B. The Manufacturer shall provide with the shop drawing submittal one signed and dated original of the fully completed Certification Letter (a sample copy of which is provided in the Appendix of this manual). Said form shall demonstrate compliance with Section 436 of federal H.R. 3547. Submit in accordance with Section 01 33 00.

PART 2 – PRODUCTS

2.01 GENERAL

A. Provide shop-fabricated grating and accessories such as frames, support angles, fasteners, and treads.

B. Grating and treads shall be serrated aluminum.

C. Treads and exposed edges of grating platforms shall have corrugated or cast aluminum abrasive nosing.

D. Provide fastening devices to firmly anchor grating and treads to supports. Sections designated as removable shall not be attached to supports.

1. Minimum of 4 per panel.
2. Shall allow for repeated removal.
3. Saddle clip type.
4. "G" clip type.
5. Clamp type.
6. Minimum 1/4 inch bolts or self tapping screws.
7. 316 stainless steel.

E. Provide trim banding or load carrying banding on edges and cutouts welded to grating.

1. Bearing bars not resting on supports shall have load carrying banding sized to span opening.
2. Minimum banding thickness shall match bearing bar thickness.
3. Banding shall be flush with top of grating.
4. Banding depth shall be 1/4 inch less than bearing bar depth at supports.

F. Cross bars shall not extend more than 1/8 inch past bearing bars at panel edges.

G. Panels shall bear on supports a minimum length equal to bearing bar depth.

H. Minimum width of panels shall be 16 inches except for locations requiring a single piece.

I. Maximum width of panels shall be 48 inches.

J. Grating supports shall conform to requirements of Section 05 50 00.

2.02 ALUMINUM GRATING

A. Manufacturers:

1. IKG/Borden, Type BS.
2. Ohio Grating, Type 19-SG-4.
3. Barnett Bates, Type 19-AP-4.
4. Klemp Grating, Type KRP-19-4.

B. Materials:

1. Pressure locked serrated grating (expanded tube or swagged type).
2. Alloy 6061-T6 or 6063-T6.
3. Bearing bars shall be spaced at 1-3/16 inch on center.
4. Cross bars shall be spaced at 4 inch on center.
5. Size bearing bars as follows:

Maximum Clear Span (ft - in.)	**Bearing Bar Size** (depth below serrations) (in.)
3 - 8	1-1/4 x 1/8

4 - 3	1-1/4 x 3/16
4 - 5	1-1/2 x 1/8
5 - 1	1-1/2 x 3/16
5 - 11	1-3/4 x 3/16
6 - 2	2 x 3/16
6 - 11	2-1/4 x 3/16
7 - 9	2-1/2 x 3/16
in.= inch ft = feet	

PART 3 – EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 INSTALLATION

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

B. Clearances:

1. 1/4 inch maximum from metal sections.
2. 1/2 inch maximum from concrete or masonry walls.
3. 1/4 inch maximum between sections.

END OF SECTION

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DIVISION 06

WOOD, PLASTICS, AND COMPOSITES

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SECTION 06 10 00
ROUGH CARPENTRY

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Wood blocking and nailers.
2. Plywood backing panels.

1.02 DEFINITIONS

A. Rough Carpentry: Carpentry work not specified as part of other sections and generally not exposed, except as otherwise indicated.

1.03 REFERENCES

A. ALSC: American Lumber Standard Committee

B. APA: American Planning Association

C. ASTM: American Society for Testing and Materials

D. AWPA: American Wood Protection Association

1.04 QUALITY ASSURANCE

A. Lumber Standards: Comply with PS 20 and applicable grading rules of inspection agencies certified by ALSC Board of Review.

B. Grade Stamps: Factory-mark each piece of lumber with grade stamp of inspection agency evidencing compliance with grading rule requirements and identifying grading agency, grade, species, and moisture content at time of surfacing, and mill.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Keep materials under cover and dry. Protect against exposure to weather and contact with damp or wet surfaces.

PART 2 - PRODUCTS

2.01 LUMBER, GENERAL

A. Nominal sizes indicated except as shown by detail dimensions.

B. Provide dressed lumber, S4S, unless otherwise indicated.

C. Provide seasoned lumber with 19% maximum moisture content at time of dressing and shipment, unless otherwise indicated.

2.02 DIMENSION LUMBER

A. Provide "stud" or "standard" grade lumber for wood blocking and nailers; any species.

2.03 MISCELLANEOUS LUMBER

A. Provide Standard Grade wood for support or attachment of other Work including cant strips, bucks, nailers, blocking, furring, grounds, stripping, and similar members. Provide lumber of sizes indicated, worked into shapes shown.

2.04 PLYWOOD SHEATHING

A. General:

1. Comply with PS 1.
2. Factory-mark each panel with APA trademark evidencing compliance with grade requirements.

B. Plywood Backing Panels:

1. For mounting electrical or telephone equipment, provide fire-retardant treated plywood panels with trade designation, APA C-D plugged interior with exterior glue in thickness indicated.

2.05 MISCELLANEOUS MATERIALS

A. Fasteners and Anchorages:

1. Provide size, type, material, and finish indicated and recommended by applicable standards, complying with applicable Federal Specifications for nails, staples, screws, bolts, nuts, washers, and anchoring devices.
2. Provide metal hangers and framing anchors of size and type recommended by manufacturer for each use, including recommended nails.
3. Where rough carpentry work exposed to weather, in-ground contact or area of high relative humidity, provide fasteners and anchorages with hot-dip zinc coating (ASTM A153).

2.06 WOOD TREATMENT BY PRESSURE PROCESS

A. Preservative Treatment:

1. Where lumber or plywood indicated "treated," or specified herein to be treated, comply with applicable requirements of AWPA C1, C2, and C9. Mark each treated item with AWPA quality mark requirements.
2. Preservative: CA-B (Copper Azole Type B).
3. Pressure-treat above ground items to minimum retention of 0.25. After treatment, kiln-dry lumber and plywood to maximum moisture content, respectively, of 19% and 15%. Treat indicated items and following.

   a. Wood nailers, curbs, blocking, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.
   b. Wood sills, blocking, and similar concealed members in contact with masonry or concrete.
   c. Wood framing members less than 18 inches above grade.

4. Complete fabrication of treated items prior to treatment, where possible. If cut after treatment, coat cut surfaces with heavy brush coat of same chemical used for treatment to comply with AWPA M4. Inspect each piece of lumber or plywood after drying and discard damaged or defective pieces.

B. Fire-Retardant Treatment:

1. Where fire-retardant treated wood indicated, pressure impregnate lumber and plywood with fire-retardant chemicals to comply with AWPA C20 and C27, respectively, for treatment type indicated below; identify lumber with appropriate classification marking of UL, U.S. Testing, Timber Products Inspection or other testing and inspecting agency acceptable to authorities having jurisdiction.
2. Interior Type A: Interior applications.
3. Exterior Type: Exterior, exposed applications.
4. Inspect each piece of treated lumber or plywood after drying and discard damaged or defective pieces.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Discard units of material with defects which might impair quality of Work and units too small to use in fabricating Work with minimum joints or optimum joint arrangement.

B. Set to required levels and lines, with members plumb and true to line and cut and fitted.

C. Securely attach carpentry work to substrate by anchoring and fastening as shown and required by recognized standards.

1. Countersink nail heads on exposed carpentry work and fill holes.
2. Use common wire nails, except as otherwise indicated. Use finishing nails for finish work. Select fasteners of size that will not penetrate members where opposite side will be exposed to view or receive finish materials. Make tight connections between members. Install fasteners without splitting of wood; predrill as required.

3.02 NAILERS AND BLOCKING

A. Provide where shown and required for screening or attachment of other Work. Form to shapes shown and cut as required for true line and level of Work to be attached. Coordinate location with other Work involved.

B. Attach to substrates as required to support applied loading. Countersink bolts and nuts flush with surfaces, unless otherwise indicated. Build into masonry during installation of masonry work. Where possible, anchor to formwork before concrete placement.

3.03 PLYWOOD SHEATHING

A. Comply with applicable recommendations contained in APA.

B. Fastening Methods: Fasten panels as indicated below.

1. Plywood Backing Panels: Nail or fasten to supports using screws with plastic inserts.

END OF SECTION

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SECTION 06 74 13
FIBERGLASS REINFORCED GRATING

PART 1 – GENERAL

1.01 SUMMARY

A. Provide fiberglass grating and platforms as shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

B. Section Includes:

1. Design, fabrication, and erection of fiberglass grating and support framing.
2. System accessories.

1.02 REFERENCES

A. ASTM: American Society for Testing and Materials

B. OSHA : Occupational Safety and Health Administration

1.03 SYSTEM DESCRIPTION

A. Design Requirements:

1. Design Loads:

a. 100 pounds per square foot uniform live load.
b. 400 pounds moving concentrated live load.

2. 1/4 inch maximum deflection under 100 pounds per square foot uniform live load for grating and treads.
3. L/240 maximum deflection for support members.

1.04 SUBMITTALS

A. Shop Drawings:

1. Type, layout, dimensions, design loads, fasteners, and locations.
2. Stamped by Structural Engineer registered in State of Illinois.

B. Product Data:

1. Manufacturer's literature.

C. Submit in accordance with Section 01 33 00.

1.05 QUALITY ASSURANCE

A. Grating shall be end product of one manufacturer to achieve standardization of appearance.

PART 2 – PRODUCTS

2.01 GENERAL

A. Provide shop-fabricated grating and accessories such as frames, support angles, and fasteners.

B. Seal cut edges with compatible resin.

C. Provide fastening devices to firmly anchor grating and treads to supports. Sections designated as removable shall not be attached to supports.

1. Minimum of 4 per panel, maximum 4 feet on center.
2. Shall allow for repeated removal.
3. Minimum 1/4 inch bolts or self tapping screws.
4. 316 stainless steel or fiberglass.

D. Provide additional supports at openings in grating panels.

E. Panels shall bear on supports a minimum of 1-1/2 inches.

F. Minimum width of panels shall be 16 inches except for locations requiring a single piece.

G. Maximum width of panels shall be 60 inches.

H. Concrete anchors shall conform to requirements of Section 05 50 00.

2.02 PLANK GRATING

A. Manufacturers:

1. Safeplank by Stongwell
2. Superplank by Creative Pultrusions, Inc.
3. Or equal.

B. Materials:

1. 2 in. deep maximum pultruded plank.
2. Premium polyester resin, continuous glass filament reinforcement.
3. Resin rich exterior surfaces free of air bubbles and dry glass.
4. Meet self extinguishing requirements of ASTM D635 and have Class 1 flame spread rating (tunnel test) of 25 or less in accordance with ASTM E84.
5. UV inhibited with surfacing veil on exposed surfaces.
6. Walkway surface shall have a skid-resistant gritted finish.
7. Plank panels shall have interlocking joints on outside legs of planks.

2.03 GRATING SUPPORT ANGLES

A. Fiberglass angles especially fabricated to be cast into the concrete to provide a suitable bearing ledge to support the grating.

B. Support angles shall be supplied by the grating manufacturer.

C. The angle materials shall meet the criteria established for Structural Shapes as described herein.

2.04 STRUCTURAL SHAPES

A. Manufacturers:

1. Dynaform by Fibergrate.
2. Pultex Series by Creative Pultrusions, Inc.
3. Extren Series by Strongwell.
4. Or equal.

B. Materials:

1. Pultruded fiberglass angles, channels, and other structural shapes.
2. Reinforcement shall consist of combination fiberglass roving, continuous strand, and veil material.
3. Premium polyester UV inhibited resin with surface veil on all faces.
4. Resin rich exterior surfaces free of air bubbles and dry glass.

2.05 ACCESSORIES

A. Bolts, rivets, and other connectors shall be 316 SST.

B. Concrete anchors shall be stainless steel conforming to requirements of Section 05 50 00.

PART 3 – EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 INSTALLATION

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

B. Clearances:

1. 1/4 inch maximum from metal sections.
2. 1/2 inch maximum from concrete or masonry walls.
3. 1/4 inch maximum between sections.

C. Seal cut edges with compatible resin.

END OF SECTION

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DIVISION 07

THERMAL AND MOISTURE PROTECTION

SECTION 07 21 00
THERMAL INSULATION

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Board insulation at perimeter concrete foundation walls.
2. Board insulation in masonry cavity walls.
3. Roof board insulation.

1.02 REFERENCES

A. ASTM: American Society for Testing and Materials

1.03 PERFORMANCE REQUIREMENTS

A. Materials of this section shall provide continuity of thermal barrier at building enclosure elements.

1.04 SUBMITTALS

A. Product Data: Provide data on product characteristics, performance criteria, and limitations.

B. Manufacturer's installation instructions.

C. Submit in accordance with section 01 33 00.

1.05 ENVIRONMENTAL CONDITIONS

A. Do not install insulation adhesives when temperatures or weather conditions are detrimental to successful installation.

PART 2 - PRODUCTS

2.01 EXTRUDED POLYSTYRENE BOARD (PERIMETER FOUNDATION WALL INSULATION)

A. Rigid, closed-cell, extruded, polystyrene insulation with integral high density skins.

B. Minimum thermal resistance "R" per inch: 5.0.

C. Minimum compressive strength:

1. 25 pounds per square inch for perimeter wall and cavity wall insulation.
2. 100 pounds per square inch for sandwich slab insulation.

D. Maximum water absorption by volume in accordance with ASTM C272: 0.1%.

E. Manufacturer's recommended adhesive for insulation application.

F. Minimum thickness: 2 inches unless otherwise noted. Reduce thickness of cavity wall insulation at concrete beams and columns to 1 ½ inches.

G. Acceptable Manufacturers:

1. Dow.
2. Owens Corning.
3. Tenneco.
4. Pactiv.

2.02 FOIL FACED POLYISOCYANURATE INSULATION BOARD (CAVITY WALL INSULATION)

A. Rigid closed cell polyisocyanurate foam core laminated to high performance aluminum foil facers. Manufactured with HCFC-free blowing agent and formaldehyde free.

1. Thermal Resistance: Aged R-Value per inch of 6.5. (13.1 per 2 inches).
2. Water Vapor Transmission: 0.03 perms per inch per ASTM E96.
3. Water Absorption: 0.057% by volume per ASTM C209.
4. Surface Burning Characteristics: Less than 25 flame spread and less than 450 smoke developed per ASTM E84.
5. Compressive Strength: 25 psi per ASTM D1621.
6. Density: 2% per ASTM D1622.

B. Acceptable Manufacturers

1. Atlas Roofing Corporation.
2. Dow
3. RMAX
4. Hunter

2.03 COATED GLASS FACED POLYISOCYANURATE INSULATION BOARD (TPO MEMBRANE ROOF INSULATION)

A. Rigid closed cell polyisocyanurate foam core laminated to high performance coated fiberglass mat facers. Manufactured with HCFC-free blowing agent and formaldehyde free.

1. Thermal Resistance: Aged R-Value per inch of 6.0. (15.1 per 2-1/2 inches).
2. Water Vapor Transmission: Less than 1 perm per inch per ASTM E96.
3. Water Absorption: 1.277% by volume per ASTM C209.
4. Surface Burning Characteristics: Less than 25 flame spread and less than 450 smoke developed per ASTM E84.
5. Compressive Strength: 20 psi per ASTM D1621.
6. Density: 2% per ASTM D1622.

B. Acceptable Manufacturers

1. Atlas Roofing Corporation.
2. Dow
3. RMAX
4. Hunter

PART 3 - EXECUTION

3.01 INSTALLATION / EXTRUDED POLYSTYRENE AND POLYISOCYANURATE BOARD INSULATION

A. Extruded polystyrene insulation to be installed where shown on the drawings, in accordance with manufacturer's instructions.

B. Place boards in method to maximize contact bedding. Stagger side and end joints with edges

butted tightly.

C. Cut and fit boards tightly around penetrations and other openings as required.

D. Perimeter insulation shall be set in adhesive applied to foundation wall in accordance with manufacturer's recommendations.

E. Cavity wall insulation shall be set in adhesive applied to exterior face of interior wythe in accordance with manufacturer's recommendations. Fit courses of insulation between wall ties between wythes.

F. Where thickness exceeds 2 inches, install first layer of insulation as specified herein. Stagger side and end joints of finish layer.

END OF SECTION

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SECTION 07 21 19
FOAMED-IN-PLACE INSULATION

PART – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Foamed-in-place Insulation for exterior concrete masonry walls as noted on Drawings.

1.02 REFRENCES

A. ASTM: American Society for Testing and Materials

1.03 SUBMITTALS

A. Product data, technical information, and installation instructions.

B. Certified test reports showing compliance with specified performance values.

C. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Provide insulation produced by a single manufacturer.

B. Engage an experienced installer who has been trained and licensed by the product manufacturer and which has not less than three years experience in the installation of the product used.

C. Provide insulation materials which meet fire performance characteristics listed.

1. Fire Resistance Ratings: ASTM E-119
2. Surface Burning Characteristics: ASTM E-84
3. Combustion Characteristics: ASTM E-136

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Core-Fill 500 by Tailored Chemical Products.

B. Tripolymer Foam Insulation by C.P. Chemical Co., Inc.

C. Thermco Foam Insulation by Thermal Corp. of America.

2.02 INSULATING MATERIALS

A. Provide insulating materials which comply with requirements indicated, referenced standards, and other characteristics.

B. Two component thermal insulation produced by combining a plastic resin and catalyst foaming agent which, when properly rationed and mixed, together with compressed air produce a cold-setting rigid foam insulation in the hollow cores of hollow unit masonry walls.

1. Minimum 2 hour fire resistance rating when tested as a wall system.
2. Maximum flame spread, smoke developed, and fuel contributed of 15, 75 and 0 respectively.
3. Minimum “R” Value: 4.7 inches. at 32°F; ASTM C-177.
4. Minimum Sound Transmission Class (“STS”) Rating: 50.
5. Dry Density: 0.7 to 1.3 per cubic feet.
6. Minimum Compressive Strength: 30 pounds per square inch.
7. Maximum Shrinkage: 2%.

C. Foam must be a noncombustible, Class A building material, shall be non-corrosive, shall not conduct electricity, shall not absorb water, shall be non-toxic, and shall not contain or emit CFCs.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install foamed-in-place insulation prior to installation of interior finish work; comply with manufacturer’s instructions.

B. Completely fill all open cells and voids in hollow concrete masonry walls where noted on Drawings.

C. Allow foam to cure minimum of 2 weeks before coating or sealing walls.

END OF SECTION

SECTION 07 26 20
SELF-ADHERING AIR/VAPOR BARRIER

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. This section includes following:

1. Materials and installation methods for rolled, self-adhering air/vapor barrier system.
2. Materials and installation to bridge and seal following air leakage pathways and gaps:

a. Connections of walls to roof air barrier.
b. Connections of walls to foundations.
c. Openings and penetrations of window frames and aluminum entrances.
d. Hollow metal door frames.
e. Piping, conduit, duct and similar penetrations.
f. Masonry ties, screws, bolts and similar penetrations.
g. All other air leakage pathways in building envelope.

1.02 SECTION INCLUDES

A. Provide air/vapor barrier constructed to perform as continuous air/vapor barrier, and as liquid water drainage plane flashed to discharge to exterior any incidental condensation or water penetration. Membrane shall accommodate movements of building materials by providing expansion and control joints as required, with accessory air seal materials at such locations, changes in substrate and perimeter conditions.

B. Air Barrier Association of America's (ABAA' s) definition of tested system, to provide tested system air leakage results not to exceed:

1. 0.01 cfm/sf @ 1.57 psf (0.05 L/s?M2 @ 75 Pa).
2. 0.02 cfm/sf @ 1.57 psf (0.1 L/s/M2 @ 75 Pa).
3. 0.03 cfm/sf @ 1.57 psf (0.15 L/s/M2 @ 75 Pa).
4. 0.04 cfm/sf @ 1.57 psf (0.2 L/s/M2 @ 75 Pa).

1.03 SUBMITTALS

A. Provide submittals in accordance with Section 01 33 00 and the following:

1. Provide evidence to contractor of licensing and certification under Air Barrier Association of America's (ABAA's) Quality Assurance Program.
2. Submit shop drawings showing locations and extent of air/vapor barrier and details of all typical conditions, intersections with other envelope systems and materials, membrane counter-flashings, and details showing how gaps in construction will be bridged, how inside and outside corners are negotiated and how miscellaneous penetrations such as conduits, pipes, electric boxes and similar items are sealed.
3. Submit manufacturer's product data sheets for each type of membrane, including manufacturer's printed instructions for evaluating, preparing, and treating substrate, temperature and other limitations of installation conditions, technical data, and tested physical and performance properties.
4. Submit manufacturer's installation instructions.
5. Certification by air/vapor barrier manufacturer that products supplied comply with local regulations controlling use of volatile organic compounds (VOCs).

6. Certification of compatibility by air/vapor barrier manufacturer, listing all materials on project that it connects to or that come in contact with it.
7. Submit samples, 3 in. by 4 in. minimum size, of each air/vapor barrier material required for Project.

1.04 QUALITY ASSURANCE

A. Installer Qualifications:

1. Air barrier contractor shall be, during bidding period as well as for duration of installation, officially recognized as Licensed Contractor by Air Barrier Association of America (ABAA).
2. Each worker who is installing air barriers must be either Certified Applicator or an installer who is registered with ABAA.

B. Air/vapor barrier installers must be trained and certified by NECA (National Energy Conservation Association) and PSDI (Professional Skills Development Institute for energy conservation).

C. Single-Source Responsibility: Obtain air/vapor barrier materials from single manufacturer regularly engaged in manufacturing product.

D. Provide products which comply with all state and local regulations controlling use of volatile organic compounds (VOCs).

E. Preconstruction Meeting: Convene one week prior to commencing Work of this section.

F. Sample Panel: Prior to installation of air/vapor barrier, apply air/vapor barrier as follows to verify details under shop drawings submittals and to demonstrate tie-ins with adjoining construction, and other termination conditions, as well as qualities of materials and execution:

1. Apply air/vapor barrier in sample panel of typical exterior wall panel.
2. Typical exterior sample wall panel shall be 8 ft. long by 8 ft. wide, incorporating backup wall, cladding, window and door frame and sill, insulation, flashing, junction with roof system, foundation wall and typical penetrations and gaps; illustrating materials interface and seals.
3. Test mock-up for air and water infiltration in accordance with ASTM E 7983 and ASTM E1 105.
4. Do not cover any installed air and vapor barrier membrane unless it has been inspected, tested and approved.
5. Do not start Work until CONTRACTOR has accepted sample panel.
6. Use panel as standard of comparison for stonework built of same material.
7. Do not destroy or move panel until Work complete and accepted by CONTRACTOR.
8. Sample panel may be part of finished wall.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in original packages with seals unbroken, labeled with manufacturer's name, product, date of manufacture, and directions for storage.

B. Store materials in their original undamaged packages in clean, dry, protected location and within temperature range required by air/vapor barrier manufacturer. Protect stored materials from direct sunlight.

C. Avoid spillage. Immediately notify CONTRACTOR if spillage occurs and start clean up procedures.

D. Clean spills and leave area as it was prior to spill.

1.06 DISPOSAL

A. Place materials defined as hazardous or toxic waste in designated containers. Ensure emptied containers are sealed and stored safely for disposal.

1.07 PROJECT CONDITIONS

A. Environmental Conditions: Apply air/vapor barrier within range of ambient and substrate temperatures recommended by air/vapor barrier manufacturer. Do not apply air/vapor barrier to damp or wet substrate, unless manufacturer specifically permits that for product.

1. Do not apply air/vapor barrier in snow, rain, fog, or mist.
2. Do not apply air/vapor barrier when temperature of substrate surfaces and surrounding air temperatures are below those recommended by manufacturer.
3. Do not apply to frozen surfaces.
4. Product not intended for uses subject to abuse or permanent exposure to the elements.
5. Protect rolls from direct sunlight until ready for use.

PART 2 – PRODUCTS

2.01 MATERIALS AND MANUFACTURERS

A. AIR-SHIELD Self-Adhering Air/Vapor and Liquid Moisture Barrier. L W. R. MEADOWS, INC., PO Box 338, Hampshire, Illinois 60140-0338. (800) 342-5976. (847) 683-4500. Fax (847) 683-4544. Website: www.wrmeadows.com.

B. Rolled, Self-Adhering Air/Vapor Barrier Membrane: Roll-type 40-mil thick polymeric air/vapor barrier membrane protected by release paper on cross-laminated polyethylene carrier film with exposed polymeric membrane strips on both sides protected by pull-off release strips.

1. Air/Vapor barrier membrane shall have the following characteristics:

a. Air Leakage, ASTM E2357: ≤0.04 cfm / ft.^{2} @ 75 Pa (1.57 lb./ft.^{2}).
b. Air Permeability, ASTM E2178: ≤0.004 cfm / ft.^{2} @ 75 Pa (1.57 lb./ft.^{2}).
c. Water Vapor Permeance, ASTM E96 (Method B): ≤0.035 perms.
d. Elongation, ASTM D412: 400%.
e. Tensile Strength, ASTM D412: 4000 psi (27.6 MPa).
f. Lap Peel Strength @ 39^o F (4^o C), ASTM D903, 180 Bend: 10 lbf/in. (1.75 N/mm).
g. Service Temperature: -40^o F to 158^o F.
h. Puncture Resistance, ASTM E154: 40 lbf (1.78 N) Min.
i. Application Temperature: 40^o F (4^o C) Min..
j. Piability @ -25^o F (-32^o C): No effect.

2.02 ACCESSORIES

A. Furnish auxiliary materials recommended by air/vapor barrier manufacturer for intended use and compatible with air/vapor barrier membrane.

B. Flashing and Transition Membrane: Self-adhesive polymeric sheet membrane having a thickness of 40 mils (1 mm).

1. Air-Shield Thru-Wall Flashing by W. R. Meadows or equal.

C. Liquid Flashing: Fluid applied, single component, flashing membrane for rough openings and detailing.

1. Air-Shield Liquid Flashing by W. R. Meadows or equal.

D. Joint Tape: Self-adhering flexible roll-type 25 mil polymeric membrane flashing tape.

1. Air-Shield 25-Mil Flashing Tape by W. R. Meadows or equal.

E. Membrane Adhesive:

1. Temperatures above 40° F (4° C): Water-Based Adhesive

a. MEL-PRIME™ W/B Water-Based Adhesive by W. R. Meadows or equal.

2. Temperatures below 30° F (-1° C): Solvent-Based Primer.

a. MEL-PRIME VOC Compliant Solvent-Based Adhesive or Standard Solvent-Base Adhesive by W. R. Meadows or equal.

F. Pointing Mastic: Mastic for sealing penetrations and terminations of membrane.

1. Pointing Mastic by W. R. Meadows or equal.

G. Detailing Membrane: Non-slump waterproofing material for joint detailing.

1. BEM by W. R. Meadows or equal.

H. Concrete Repair Materials: General purpose patching materials.

1. MEADOW-PATCH 5 and MEADOW-PATCH 20 Concrete Repair Mortars by W. R. Meadows or equal.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions under which air/vapor barrier systems will be applied, with Installer present, for compliance with requirements. Verify that surfaces and conditions are suitable prior to commencing work of this section. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 SURFACE PREPARATION

A. Protect adjacent surfaces not designated to receive air/vapor barrier system
.

B. Clean and prepare surfaces to receive air barrier in accordance with manufacturer's instructions.

C. Do not apply air/vapor barrier to surfaces unacceptable to manufacturer.

D. All surfaces must be clean, smooth, and dry and must be clean of oil, dust, and excess mortar.

E. Strike masonry joints flush.

F. Patch all holes and voids and smooth out any surface misalignments
.

G. Concrete surfaces must be cured for a minimum of 14 days.

H. If curing compounds are used, they must be clear, resin based, without oil, wax, or pigments.

1. Do not proceed with installation until after minimum concrete curing period recommended by air/vapor barrier manufacturer.
2. Ensure that:

a. Surfaces are sound, dry, even, and free of oil, grease, dirt, excess mortar or other contaminants.
b. Concrete surfaces are cured and dry, smooth without large voids, spalled areas or sharp protrusions.
c. Masonry joints are flush and completely filled with mortar, and all excess mortar

3. Verify substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D4263.

4. Notify CONTRACTOR in writing of anticipated problems using air/vapor barrier over substrate.

3.03 INSTALLATION

A. Transition Membrane:

1. Prime the area to be detailed using adhesive recommended by the membrane manufacturer according to the substrate.
2. Apply transition membrane with a minimum overlap of 3” (75 mm) onto primed surface at all joints, columns, and beams as indicated in drawings.
3. Tie in to door openings, roofing systems, floor intersections, and dissimilar materials.
4. Roll membrane firmly into place.
5. Ensure membrane is fully adhered and remove all wrinkles and fish mouths.
6. Overlap subsequent courses of membrane a minimum of 2” (50 mm) and ensure joints are fully adhered.
7. Seal top edge of transition membrane with pointing mastic.

B. Through Wall Flashing:

1. Prime the area to be detailed using adhesive recommended by the membrane manufacturer according to the substrate.
2. Remove release paper prior to application.
3. Apply through wall flashing at base of masonry walls as indicated on Drawings.
4. Recess through wall flashing 1/2 in. from the face of the masonry.
5. Apply a bead of pointing mastic if through wall flashing is not embedded into masonry.

C. Air Barrier membrane:

1. Apply air barrier membrane system in accordance with manufacturer’s instructions.
2. Ensure accessory materials are compatible with membrane and approved by membrane manufacturer.

3. Prime the area to be detailed using adhesive recommended by the membrane manufacturer according to the substrate. Re-apply adhesive to uncovered surfaces next day.
4. Apply membrane to primed surface by removing release paper and rolling membrane firmly into place.
5. Ensure membrane is fully adhered and remove all wrinkles and/or fish mouths.
6. Cut air barrier membrane to detail around protrusions and masonry reinforcing.
7. Overlap subsequent courses of membrane a minimum of 2" (50 mm) in a shingle fashion.
8. Inspect membrane before covering and repair as necessary. Cover tears and inadequate overlaps with membrane. Seal edges of patches with pointing mastic.
9. Seal all end laps and protrusions with pointing mastic.
10. Avoid use of products which contain tars, solvents, pitches, polysulfide polymers, or PVC materials that may come into contact with waterproofing membrane system.

3.04 PROTECTION

A. Protect air/vapor barrier system from damage during application and remainder of construction period, according to manufacturer's written instructions.

B. Cover air barrier membrane from exposure to elements as required by manufacturer.

END OF SECTION

SECTION 07 54 00
THERMOPLASTIC MEMBRANE ROOFING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes following:

1. Fully adhered membrane roofing system.
2. Air/vapor barrier.
3. Roof insulation.
4. Walkway roof pads.
5. Counterflashing.
6. Copings.
7. Fascia.

B. This Section includes installation of acoustical roof deck rib insulation strips furnished under Division 5 Section "Steel Deck."

1.03 DEFINITIONS

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

B. Design Uplift Pressure: Uplift pressure, calculated according to procedures in SPRI's "Wind Load Design Guide for Fully Adhered and Mechanically Fastened Roofing Systems," before multiplication by safety factor.

C. Factored Design Uplift Pressure: Uplift pressure, calculated according to procedures in SPRI's "Wind Load Design Guide for Fully Adhered and Mechanically Fastened Roofing Systems," after multiplication by safety factor.

1.04 PERFORMANCE REQUIREMENTS

A. General: Provide installed roofing membrane and base flashings that remain watertight; do not permit passage of water; and resist specified uplift pressures, thermally induced movement, and exposure to weather without failure.

B. Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by roofing membrane manufacturer based on testing and field experience.

C. Roofing System Design: Provide membrane roofing system that is identical to systems that have been successfully tested by qualified testing and inspecting agency to resist uplift pressure calculated according to ASCE 7.

D. FMG Listing: Provide roofing membrane, base flashings, and component materials that comply with requirements in FMG 4450 and FMG 4470 as part of membrane roofing system

and that are listed in FMG's "Approval Guide" for Class 1 or noncombustible construction, as applicable. Identify materials with FMG markings.

1. Fire/Windstorm Classification: Class 1A-90.
2. Hail Resistance: SH.

E. Roofing System Design: Provide membrane roofing system that is identical to systems that have been successfully tested by qualified testing and inspecting agency to resist factored design uplift pressures calculated according to SPRI's "Wind Load Design Guide for Fully Adhered and Mechanically Fastened Roofing Systems."

1.05 SUBMITTALS

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

B. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other Work.

1. Base flashings and membrane terminations.
2. Tapered insulation, including slopes.
3. Insulation fastening patterns.

C. Installer Certificates: Signed by roofing system manufacturer certifying that Installer is approved, authorized, or licensed by manufacturer to install roofing system.

D. Manufacturer Certificates: Signed by roofing manufacturer certifying that roofing system complies with requirements specified in "Performance Requirements" Article.

1. Submit evidence of meeting performance requirements.

E. Qualification Data: For Installer and manufacturer.

F. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by qualified testing agency, for components of roofing system.

G. Research/Evaluation Reports: For components of membrane roofing system.

H. Maintenance Data: For roofing system to include in maintenance manuals.

I. Warranties: Special warranties specified in this Section.

J. Inspection Report: Copy of roofing system manufacturer's inspection report of completed roofing installation.

K. American Iron and Steel Compliance Certification:

1. This project is being funded by the Clean Water State Revolving Fund that requires that all of the iron and steel products used in the project to be produced in the United States (“American Iron and Steel Requirement”). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R. 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.

2. The Manufacturer shall provide with the shop drawing submittal one signed and dated Certification Letter (a sample copies of which are provided in the Appendix). The Certification Letter shall demonstrate compliance with Section 436 of federal H.R. 3547.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: Qualified firm that is approved, authorized, or licensed by roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's warranty.

B. Any company associated with Albert J. Wagner & Sons, LLC is not allowed to bid this work.

C. Manufacturer Qualifications: Qualified manufacturer that has UL listing for membrane roofing system identical to that used for this Project.

D. Testing Agency Qualifications: Independent testing agency with experience and capability to conduct testing indicated, as documented according to ASTM E 548.

E. Fire-Test-Response Characteristics: Provide membrane roofing materials with fire-test-response characteristics indicated as determined by testing identical products per test method below by UL, FMG, or another testing and inspecting agency acceptable to authorities having jurisdiction. Materials shall be identified with appropriate markings of applicable testing and inspecting agency.

1. Exterior Fire-Test Exposure: Class A; ASTM E 108, for application and roof slopes indicated.
2. Fire-Resistance Ratings: ASTM E 119, for fire-resistance-rated roof assemblies of which roofing system is part.

F. Preliminary Roofing Conference: Before starting roof deck construction, conduct conference at Project site. Review methods and procedures related to roof deck construction and roofing system including, but not limited to, following:

1. Meet with Owner, Architect, Owner's insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, deck Installer, and installers whose work interfaces with or affects roofing including installers of roof accessories and roof-mounted equipment.
2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.
3. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
4. Examine deck substrate conditions and finishes for compliance with requirements, including flatness and fastening.
5. Review structural loading limitations of roof deck during and after roofing.
6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that will affect roofing system.
7. Review governing regulations and requirements for insurance and certificates if applicable.
8 Review temporary protection requirements for roofing system during and after installation.
9. Review roof observation and repair procedures after roofing installation.

G. Preinstallation Conference: Conduct conference at Project site. Review methods and procedures related to roofing system including, but not limited to, following:

1. Meet with Owner, Architect, Owner's insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, deck Installer, and installers whose work interfaces with or affects roofing including installers of roof accessories and roof-mounted equipment.
2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.
3. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
4. Examine deck substrate conditions and finishes for compliance with requirements, including flatness and fastening.
5. Review structural loading limitations of roof deck during and after roofing.
6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that will affect roofing system.
7. Review governing regulations and requirements for insurance and certificates if applicable.
8. Review temporary protection requirements for roofing system during and after installation.
9. Review roof observation and repair procedures after roofing installation.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, and directions for storing and mixing with other components.

B. Store liquid materials in their original undamaged containers in clean, dry, protected location and within temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.

1. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.

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

D. Handle and store roofing materials and place equipment in manner to avoid permanent deflection of deck.

1.08 PROJECT CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.

1,09 WARRANTY

A. Special Warranty: Manufacturer's standard form, without monetary limitation, in which manufacturer agrees to repair or replace components of membrane roofing system that fail in materials or workmanship within specified warranty period. Failure includes roof leaks.

1. Special warranty to be “Total System Warranty” which includes all products supplied by manufacturer.
2. Warranty Period: 15 yrs from date of Substantial Completion.

B. Special Project Warranty: Submit roofing Installer's warranty, on warranty form at end of this Section, signed by Installer, covering Work of this Section, including all components of membrane roofing system such as roofing membrane, base flashing, roof insulation, fasteners, cover boards, substrate boards, vapor retarders, roof pavers, and walkway products, for following warranty period:

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

1. Available Products: Subject to compliance with requirements, products that may be incorporated into Work include, but are not limited to, products specified.
2. Products: Subject to compliance with requirements, provide one of products specified.
3. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into Work include, but are not limited to, manufacturers specified.
4. Manufacturers: Subject to compliance with requirements, provide products by manufacturers specified.

2.02 THERMOPLASTIC POLYOLEFIN ROOFING MEMBRANE

A. Fabric-Reinforced Thermoplastic Polyolefin Sheet: Uniform, flexible sheet formed from thermoplastic polyolefin, internally fabric or scrim reinforced, and as follows:

1. Manufacturers:

a. Carlisle SynTec Incorporated.
b. Firestone Building Products Company.
c. GAF Materials Corporation.
d. Johns Manville International, Inc.

2. Thickness: 60 mils, nominal.
3. Exposed Face Color: White.
4. Physical Properties:

a. Breaking Strength: 225 lbf (1 kN); ASTM D 751, grab method.
b. Elongation at Break: 15 percent; ASTM D 751.
c. Tearing Strength: 55 lbf (245 N) minimum; ASTM D 751, Procedure B.
d. Brittleness Point: Minus 22 deg F (30 deg C).
e. Ozone Resistance: No cracks after sample, wrapped around 3-in.- (75-mm-) diameter mandrel, is exposed for 166 hours to temperature of 104 deg F (40 deg C) and an ozone level of 100 pphm (100 mPa); ASTM D 1149.
f. Resistance to Heat Aging: 90 percent minimum retention of breaking strength, elongation at break, and tearing strength after 166 hours at 240 deg F (116 deg C); ASTM D 573.
g. Water Absorption: Less than 4 percent mass change after 166 hours' immersion at 158 deg F (70 deg C); ASTM D 471.
h. Linear Dimension Change: Plus or minus 2 percent; ASTM D 1204.

2.03 AUXILIARY MATERIALS

A. General: Auxiliary materials recommended by roofing system manufacturer for intended use and compatible with membrane roofing.

1. Liquid-type auxiliary materials shall meet VOC limits of authorities having jurisdiction.

B. Sheet Flashing: Manufacturer's standard sheet flashing of same material, type, reinforcement, thickness, and color as PVC sheet membrane.

C. Sheet Flashing: Manufacturer's standard unreinforced thermoplastic polyolefin sheet flashing, of same color as sheet membrane.

D. Bonding Adhesive: Manufacturer's standard bonding adhesive for membrane, and solvent-based bonding adhesive for base flashings.

E. Slip Sheet: Manufacturer's recommended slip sheet, of type required for application.

F. Metal Termination Bars: Manufacturer's standard predrilled stainless-steel or aluminum bars, approximately 1 by 1/8 .in. 25 by 3 mm) thick; with anchors.

G. Metal Termination Bars: Manufacturer's standard predrilled stainless-steel or aluminum bars, approximately 1 by 1/8 .in. 25 by 3 mm) thick; with anchors.

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

I. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, T-joint covers, termination reglets, cover strips, and other accessories.

J. Recovery Board: 1/2 inch high density fiberboard, ASTM C208, R 1.39 @ 2”.

2.04 AIR/VAPOR BARRIER

A. Polyethylene air/vapor barrier: ASTM D 4397, 6 mils (0.15 mm) thick, minimum, with maximum permeance rating of 0.13 perm (7.5 ng/Pa x s x sq. m).

1. Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.
2. Adhesive: Manufacturer's standard lap adhesive, FMG approved for vapor-retarder application.

B. Laminated-Sheet Vapor Retarder: Kraft paper, 2 layers, laminated with asphalt and edge reinforced with woven fiberglass yarn with maximum permeance rating of 0.50 perm (29 ng/Pa x s x sq. m) and manufacturer's standard adhesive.

C. Glass-Fiber Felts: ASTM D 2178, Type IV, asphalt-impregnated, glass-fiber felt.

2.05 ROOF INSULATION

A. General: Provide preformed roof insulation boards that comply with requirements and referenced standards, selected from manufacturer's standard sizes and of thicknesses indicated.

B. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, felt or glass-fiber mat facer on both major surfaces.

1. Manufacturers:

a. Atlas Roofing Corporation.
b. Carlisle SynTec Incorporated.
c. Firestone Building Products Company.
d. GAF Materials Corporation.
e. Hunter Panels, LLC.
f. Johns Manville International, Inc.

C. Tapered Insulation: Provide factory-tapered insulation boards fabricated to slope of 1/4 in. per 12 in. (1:48), unless otherwise indicated.

D. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

2.06 INSULATION ACCESSORIES

A. General: Roof insulation accessories recommended by insulation manufacturer for intended use and compatible with membrane roofing.

B. Fasteners: Factory-coated steel fasteners and metal or plastic plates meeting corrosion-resistance provisions in FMG 4470, designed for fastening roof insulation to substrate, and acceptable to roofing system manufacturer.

2.06 METAL FLASHINGS

A. Counterflashing: Kynar 500 painted aluminum roll formed reglet and counterflashing in configurations shown on the drawings and as recommended by system manufacturer. Provide metal wedge inserts in wall conterflashings. Counterflashing is required over all termination bars.

1. 2-Piece Counterflashing by Metal-Era, 0.050 inch.
2. Color: Dark bronze.

B. Fascia: Kynar 500 painted aluminum, 0.050 inch. Face dimension of, and in configuration, shown on the drawings and as recommended by the system manufacturer. Factory Mutual 1-90 approved.

1. Anchor-Tite by Metal Era.
2. Color: Dark bronze.

C. Coping: Kynar 500 painted aluminum, 0.050 inch. Face dimension of, and in configuration, shown on the drawings and as recommended by the system manufacturer. Factory Mutual 1-90 approved.

1. Perma-Tite Coping by Metal Era.
2. Color: Dark bronze.

2.07 ASPHALT MATERIALS

A. Asphalt Primer: ASTM D 41.

2.08 WALKWAY ROOF PADS

A. Thermoplastic Polyolefin Walkway Pads: Reinforced roll walkway pads composed of white thermoplastic material with textured surface and smooth bottom for welding to roof membrane.

B. Size: 30 in. wide by 50 ft. long by 0,156 in. thickness.

C. Weight: 74 lb./125 sq. ft. roll.

D. Compressive Strength: 6500 psi minimum.

E. Colors and Texture: White with textured surface and smooth bottom surface.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with following requirements and other conditions affecting performance of roofing system:

1. Verify that roof openings and penetrations are in place and set and braced and that roof drains are securely clamped in place.
2. Verify that wood blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
3. Verify that surface plane flatness and fastening of steel roof deck comply with requirements in Division 5 Section "Steel Deck."
4. Verify that minimum concrete drying period recommended by roofing system manufacturer has passed.
5. Verify that concrete substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263.
6. Verify that concrete curing compounds that will impair adhesion of roofing components to roof deck have been removed.
7. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.

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

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

D. Install acoustical roof deck rib insulation strips, specified in Division 5 Section "Steel Deck," according to acoustical roof deck manufacturer's written instructions.

3.03 INSULATION INSTALLATION

A. Coordinate installing membrane roofing system components so insulation is not exposed to precipitation or left exposed at end of workday.

B. Comply with membrane roofing system manufacturer's written instructions for installing roof insulation.

C. Install tapered insulation under area of roofing to conform to slopes indicated.

D. Install one or more layers of insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 1-1/2 in. (38 mm) or greater, install 2 or more layers with joints of each succeeding layer staggered from joints of previous layer minimum of 6 in. (150 mm) in each direction.

E. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.

F. Install insulation with long joints of insulation in continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 in. (6 mm) with insulation.

1. Cut and fit insulation within 1/4 in. (6 mm) of nailers, projections, and penetrations.

G. Adhered Insulation: Install each layer of insulation and adhere to substrate as follows:

1. Prime surface of concrete deck with asphalt primer at rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.
2. Set each layer of insulation in solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
3. Set each layer of insulation in cold fluid-applied adhesive.

H. Mechanically Fastened Insulation: Install each layer of insulation and secure to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.

1. Fasten insulation according to requirements in FMG's "Approval Guide" for specified Windstorm Resistance Classification.
2. Fasten insulation to resist uplift pressure at corners, perimeter, and field of roof.

I. Mechanically Fastened and Adhered Insulation: Install each layer of insulation and secure first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.

1. Fasten first layer of insulation according to requirements in FMG's "Approval Guide" for specified Windstorm Resistance Classification.
2. Fasten first layer of insulation to resist uplift pressure at corners, perimeter, and field of roof.
3. Install subsequent layers of insulation in solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
4. Install subsequent layers of insulation in cold fluid-applied adhesive.

3.04 FULLY ADHERED ROOFING MEMBRANE INSTALLATION

A. Install roofing membrane over area to receive roofing according to membrane roofing system manufacturer's written instructions. Unroll roofing membrane and allow to relax before installing.

1. Install sheet according to ASTM D 5036.

B. Start installation of roofing membrane in presence of membrane roofing system manufacturer's technical personnel.

C. Accurately align roofing membrane and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.

D. Bonding Adhesive: Apply solvent-based bonding adhesive to substrate and underside of roofing membrane at rate required by manufacturer and allow to partially dry before installing roofing membrane. Do not apply bonding adhesive to splice area of roofing membrane.

E. Bonding Adhesive: Apply water-based bonding adhesive to substrate at rate required by manufacturer and immediately install roofing membrane. Do not apply bonding adhesive to splice area of roofing membrane.

F. Hot Roofing Asphalt: Apply solid mopping of hot roofing asphalt to substrate at temperature and rate required by manufacturer and install fabric-backed roofing membrane. Do not apply roofing asphalt to splice area of roofing membrane.

G. Mechanically or adhesively fasten roofing membrane securely at terminations, penetrations, and perimeter of roofing.

H. Apply roofing membrane with side laps shingled with slope of roof deck where possible.

I. Seams: Clean seam areas, overlap roofing membrane, and hot-air weld side and end laps of roofing membrane according to manufacturer's written instructions to ensure watertight seam installation.

1. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of roofing membrane.
2. Verify field strength of seams minimum of twice daily and repair seam sample areas.
3. Repair tears, voids, and lapped seams in roofing membrane that does not meet requirements.

J. Spread sealant or mastic bed over deck drain flange at deck drains and securely seal roofing membrane in place with clamping ring.

K. Install roofing membrane and auxiliary materials to tie in to existing roofing.

3.05 BASE FLASHING INSTALLATION

A. Install sheet flashings and preformed flashing accessories and adhere to substrates according to membrane roofing system manufacturer's written instructions.

B. Apply solvent-based bonding adhesive to substrate and underside of sheet flashing at required rate and allow to partially dry. Do not apply bonding adhesive to seam area of flashing.

C. Flash penetrations and field-formed inside and outside corners with sheet flashing.

D. Clean seam areas and overlap and firmly roll sheet flashings into adhesive. Weld side and end laps to ensure watertight seam installation.

E. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars.

3.06 METAL FLASHING INSTALLATION

A. Install sheet metal\ flashings, counterflashings, copings, fascia and accessories in accordance with manufacturer's printed instructions.

3.07 ROOF WALKWAY PAD INSTALLATION

A. Roof Walkway Pads: Install reinforced roll walkway roof pads according to manufacturer's written instructions in locations indicated on Drawings to form walkways.

3.08 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage qualified independent testing and inspecting agency to perform roof tests and inspections and to prepare test reports.

B. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion and submit report to Architect.

1. Notify Architect or Owner 48 hours in advance of date and time of inspection.

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

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

3.09 PROTECTING AND CLEANING

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

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

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

3.10 ROOFING INSTALLER'S WARRANTY

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

1. Owner: <Insert name of Owner.>
2. Address: <**Insert address.**>
3. Building Name/Type: <**Insert information.**>
4. Address: <Insert address.>
5. Area of Work: <Insert information.>
6. Acceptance Date: <**Insert date.**>
7. Warranty Period: <**Insert time.**>
8. Expiration Date: <**Insert date.**>

B. AND WHEREAS Roofing Installer has contracted (either directly with Owner or indirectly as subcontractor) to warrant said work against leaks and faulty or defective materials and workmanship for designated Warranty Period,

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

1. When work has been damaged by any of foregoing causes, Warranty shall be null and void until such damage has been repaired by Roofing Installer and until cost and expense thereof have been paid by Owner or by another responsible party so designated.
2. Roofing Installer is responsible for damage to work covered by this Warranty but is not liable for consequential damages to building or building contents resulting from leaks or faults or defects of work.
3. During Warranty Period, if Owner allows alteration of work by anyone other than Roofing Installer, including cutting, patching, and maintenance in connection with penetrations, attachment of other work, and positioning of anything on roof, this Warranty shall become null and void on date of said alterations, but only to extent said alterations affect work covered by this Warranty. If Owner engages Roofing Installer to perform said alterations, Warranty shall not become null and void unless Roofing Installer, before starting said work, shall have notified Owner in writing, showing reasonable cause for claim, that said alterations would likely damage or deteriorate work, thereby reasonably justifying limitation or termination of this Warranty.
4. During Warranty Period, if original use of roof is changed and it becomes used for, but was not originally specified for, promenade, work deck, spray-cooled surface, flooded basin, or other use or service more severe than originally specified, this Warranty shall become null and void on date of said change, but only to extent said change affects work covered by this Warranty.
5. Owner shall promptly notify Roofing Installer of observed, known, or suspected leaks, defects, or deterioration and shall afford reasonable opportunity for Roofing Installer to inspect work and to examine evidence of such leaks, defects, or deterioration.
6. This Warranty is recognized to be only warranty of Roofing Installer on said work and shall not operate to restrict or cut off Owner from other remedies and resources lawfully available to Owner in cases of roofing failure. Specifically, this Warranty shall not operate to relieve Roofing Installer of responsibility for performance of original work according to requirements of Contract Documents, regardless of whether Contract was contract directly with Owner or subcontract with Owner's General Contractor.

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

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

END OF SECTION

SECTION 07 62 00
SHEET METAL FLASHING & TRIM

PART – GENERAL

1.01 SUMMARY

A. This Section includes sheet metal flashing and rim in the following categories:

1. Concealed Thru-Wall Metal flashing.
2. Reglets.

1.02 REFERENCES

A. ASTM: American Society for Testing and Materials

B. AMACNA: Architectural Sheet Metal Manual

1.03 PERFORMANCE REQUIREMENTS

A. Install sheet metal flashing and trim to withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failing.

1.04 SUBMITTALS

A. Product Data including manufacturer's material and finish data, installation instructions, and general recommendations for each specified flashing material and fabricated product.

B. Samples of sheet metal flashing, trim, and accessory items, in the specified finish. Where finish involves normal color and texture variations, include Sample sets composed of 2 or more units showing the full range of variations expected.

1. 8-inch square Samples of specified sheet materials to be exposed as finished surfaces.
2. 6-inch long Samples of factory-fabricated products exposed as finished Work. Provide complete with specified factory finish.

C. American Iron and Steel Compliance Certification:

1. This project is being funded by the Clean Water State Revolving Fund that requires that all of the iron and steel products used in the project to be produced in the United States ("American Iron and Steel Requirement"). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R. 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.
2. The Manufacturer shall provide with the shop drawing submittal one signed and dated Certification Letter (a sample copies of which are provided in the Appendix). The Certification Letter shall demonstrate compliance with Section 436 of federal H.R. 3547.

D. Submit in accordance with the requirements of Section 01 33 00.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experience Installer who has completed sheet metal flashing and trim work similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

PART 2 – PRODUCTS

2.01 METALS

A. Stainless Steel: ASTM A167 Type 304, 26 gauge, 2D Finish, standard uncoated finish unless otherwise indicated.

2.02 CONCEALED THROUGH-WALL SHEET METAL FLASHING AND COUNTERFLASHING

A. Material: Fabricate from the following metal:

1. Stainless Steel: 26 gauge for full flashing.
2. Fabricate through-wall metal flashings embedded in masonry as follows:

a. With ribs formed in dovetail pattern at 3-inch intervals along length of flashing to provide a 3-way integral mortar bond and weep-hole drainage.

B. Available Products: Subject to compliance with requirements, products that may be incorporated in the work include, but are not limited to, the following:

C. Products: Subject to compliance with requirements, provide one of the following:

1. Cheney Flashing (Dovetail); Cheney Flashing Company, Inc.
2. Cheney Flashing (Sawtooth); Cheney Flashing Company, Inc.
3. Keystone Three-Way Interlocking Thruwall Flashing; Keystone Flashing Co.

2.03 REGLETS

A. General: Units of type, material, and profile indicated, formed to provide secure interlocking of separate reglet and counterflashing pieces and compatible with flashing indicated.

B. Masonry Type: Provide with offset top flange for embedment in masonry mortar joint.

C. Counterflashing Wind-Restraint Clips: Provide clips to be installed before counterflashing to prevent wind uplift of the counterflashing lower edge.

1. Material: Stainless Steel: 28 gauge.

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

E. Manufacturers: Subject to compliance with requirements, provide products by on of the following:

1. Fry Reglet corporation.
2. Hickman: W.P. Hickman Co.
3. Keystone Flashing Company.

2.04 MISCELLANEOUS MATERIALS AND ACCESSORIES

A. Fasteners: Same metal as sheet metal flashing or other noncorrosive metal as recommended by sheet metal manufacturer. Match finish of exposed heads with material being fastened.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions under which sheet metal flashing and trim are to be installed and verify that Work may properly commence. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. General: Unless otherwise indicated, install sheet metal flashing and trim to comply with performance requirements, manufacturer's installation instructions, and AMACNA. Anchor units of Work securely in place by methods indicated, providing for thermal expansion of metal units; conceal fasteners where possible, and set units true to line and level as indicated. Install Work with laps, joints, and seams that will be permanently watertight and weatherproof.

B. Install exposed sheet metal Work 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. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.

C. Install reglets to receive counterflashing according to the following requirements:

1. Where reglets are shown in masonry, furnish reglets for installation under Section 04 22 00 – Concrete Unit Masonry.

D. Counterflashings: Coordinate installation of counterflashings with installation of assemblies to be protected by counterflasing. Install counterflashings in reglets or receivers. Secure in a waterproof manner by means of snap-in installation and sealant, lead wedges and sealant, interlocking folded seam, or blind rivets and sealant. Lap counterflashing joints a minimum of 2 inches and bed with sealant.

3.03 CLEANING AND PROTECTION

A. Clean exposed metal surfaces, removing substances that might cause corrosion of metal or deterioration of finishes.

B. Provide final protection and maintain conditions that ensure sheet metal flashing and trim Work during construction is without damage or deterioration other than natural weathering at the time of Substantial Completion.

END OF SECTION

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SECTION 07 71 33
SCUPPERS

PART 1 - GENERAL

1.01 SUMMARY

A Section includes:

1. Prefinished aluminum relief (overflow) scupper.

1.02 REFERENCES

A. ASTM: American Society for Testing and Materials

B. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association

1.03 DELIVERY. STORAGE, AND HANDLING

A. Stack preformed and prefinished material to prevent twisting, bending, or abrasion, and to aid ventilation. Slope to drain.

B. Prevent contact with materials during storage which may cause discoloration, staining, or damage.

1.04 AMERICAN IRON AND STEEL

A. This project is being funded with monies made available by the Safe Drinking Water Loan Program that has statutory requirements commonly known as “American Iron and Steel;” that requires that all of the iron and steel products used in the project to be produced in the United States (“American Iron and Steel Requirement”). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.

B. The Manufacturer shall provide with the shop drawing submittal one signed and dated original of the fully completed Certification Letter (a sample copy of which is provided in the Appendix of this manual). Said form shall demonstrate compliance with Section 436 of federal H.R. 3547. Submit in accordance with Section 01 33 00.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Aluminum Sheet: ASTM B209, prefinished with Kynar 500 coating.

2.02 COMPONENTS

A. Relief (Overflow) Scuppers: Rectangular, approximately 8 inches high x 12 inches wide minimum 0.040 in. prefinished aluminum, premanufactured or shop fabricated.

1. Color: Dark Bronze.

2.03 ACCESSORIES

A. Anchorage Devices: SMACNA requirements.

B. Scupper Anchors: Stainless steel.

2.04 FABRICATION

A. Form scuppers of profiles and size indicated and to SMACNA requirements.

B. Field measure site conditions prior to fabricating work.

C. Fabricate with required connection pieces.

D. Form sections square, true, and accurate in size, in maximum possible lengths and free of distortion or defects detrimental to appearance or performance. Allow for expansion at joints.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Beginning of installation means acceptance of substrate.

3.02 INSTALLATION

A. Join lengths with formed seams sealed watertight. Flash and seal scuppers to accessories.

END OF SECTION

SECTION 07 92 00
JOINT SEALANTS

PART 1 - GENERAL

1.01 SUMMARY

A. Preparation of joint substrates and installation of joint sealants, joint backer materials and accessories needed to ensure a complete and durable weathertight seal at locations indicated.

1.02 REFERENCES

A. ASTM: American Society for Testing and Materials

1.03 SUBMITTALS

A. Product Data:

1. Manufacturer's specifications and other data needed to prove compliance with the specified requirements.
2. Manufacturer's recommended installation procedures.
3. Catalog illustrations in sufficient detail to show installation and interface of the Work of this Section with the Work of adjacent trades.
4. Standard color card showing full range of colors available for each product exposed to view.

B. Miscellaneous:

1. Written documentation of applicator's qualifications, including reference projects of similar scope and complexity, with current phone contacts of engineers and owners for verification.
2. Certification from sealant manufacturers that their products are suitable for the use indicated and comply with specification requirements.

C. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Applicator shall be approved by sealant manufacturer and shall have at least three years experience in installing materials of types specified and shall have successfully completed at least three projects of similar scope and complexity.

B. Obtain joint sealants from single manufacturer for each different product required to ensure compatibility.

1. Provide joint sealants, joint fillers and accessory joint materials that are compatible with one another and with joint substrates under Project conditions.
2. Provide joint sealants, joint fillers and related joint materials that are nonstaining to visible joint surfaces and surrounding substrate surfaces.
3. Manufacturer shall instruct applicator in procedures for intersecting sealants.

C. Perform Work in accordance with ASTM C1193 guidelines except where more stringent requirements are indicated or specified.

D. Schedule applications of waterproofing, water repellents, and preservative finishes after sealant installation unless sealant manufacturer approves otherwise in writing. Ensure that installed sealant is allowed to cure sufficiently prior to subsequent applications.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver the materials to Site in the manufacturer's unopened containers with all labels intact and legible at time of use.

B. Maintain the products in a dry condition during delivery, storage, handling, installation, and concealment.

1.06 SUBSTRATE CONDITIONS

A. Surfaces shall be broom clean, dry, sound, and free of voids, bugholes, rockpockets, honeycombs, protrusions, excessive roughness, foreign matter, frost, ice, and other contaminants which may inhibit application or performance of the sealant system.

B. Provide joints properly dimensioned to receive the approved sealant system.

1.07 WARRANTY

A. Furnish written warranties against adhesive and cohesive failure of the sealant and against infiltration of water and air through the sealed joint for a period of 3 years from date of substantial completion.

1. Manufacturer's standard warranty covering materials.
2. Installing Subcontractor's standard warranty covering workmanship.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Tremco.

B. Sika.

C. Emseal.

D. Pecora.

E. Polyspec.

F. Or Equal.

2.02 SEALANTS

A. The sealant products listed are set as a standard of quality. Sealants of other manufacturers shall meet or exceed the characteristics of the products listed.

B. Provide colors selected by Engineer from manufacturer's standard color range.

C. Sealant Type A:

1. For interior and exterior expansion joints in vertical surfaces and horizontal surfaces in concrete tanks containing domestic wastewater.
2. Acceptable Systems:

a. Sika - Sikadur-Combiflex SG – 20 M on water side of joint.

b. Emseal – Seismic Colorseal on non-water side of joint.

D. Sealant Type B:

1. For interior and exterior joints in vertical surfaces and non-traffic horizontal surfaces; such as:

a. Control and expansion joints in concrete unit or brick masonry.
b. Metal panel joints.
c. Joints around frames of doors, windows, louvers, and other similar openings.
d. Under metal thresholds.
e. Joints in sheet metal flashings.
f. Trim or finish joints.

2. Single-component or multi-component, non-sag polyurethane sealant having 25% joint movement capability that is suitable for continuous immersion in water; comply with ASTM C920, Type S or M, Grade NS, Class 25.
3. Acceptable Sealants:

a. Tremco - Vulkem 116.
b. Tremco – Dymeric 240/240FC

E. Sealant Type C:

1. For interior and exterior joints in horizontal and sloped traffic surfaces; such as control, expansion, and isolation joints in concrete pavement and sidewalks.
2. Single-component or multi-component polyurethane sealant having a Shore A hardness of not less than 25 or more than 50 and 25% joint movement capability that is suitable for continuous immersion in water; comply with ASTM C920, Type S or M, Grade P or NS, Class 25.
3. Acceptable Sealants:

a. Tremco - Vulkem 45/245.

F. Sealant Type G:

1. In interior vertical and non-traffic horizontal surfaces requiring up to a 3-hour fire and temperature rating.
2. Gun grade silicone sealant and fire blocking designed for use in firestop applications, and rated by UL for up to 3-hour fire and hose stream test.
3. Provide fire rated joint assemblies meeting fire rating indicated, in accordance with manufacturer's recommendations.
4. Acceptable Sealant:

a. Tremco - Tremstop Fyre-Sil.

5. Acceptable Fire Blocking.

a. FBX Safing Insulation by Fibrex Insulations, Inc.

G. Sealant Type I:

1. Interior and exterior joints, excluding expansion joints, in concrete tanks containing domestic wastewater.

2. Polysulfide sealant having a Shore A hardness of not less than 25 or more than 50 and 25% joint movement capability that is suitable for continuous immersion in water; comply with ASTM C920, Type S or M, Grade NS, Class 25.
3. Joints shall be primed.
4. Acceptable Primer:

    a. As recommended by sealant manufacturer.

5. Acceptable Sealants:

    a. Pecora – Synthacalk GC2+
    b. Polyspec – Thiokol 2235M

2.03 ACCESSORIES

A. Joint Cleaner: As recommended by sealant manufacturer for substrates indicated.

B. Joint Primer: As recommended by sealant manufacturer for substrates, conditions and exposures indicated.

C. Bond Breaker: Polyethylene tape or other adhesive faced tape as recommended by sealant manufacturer to prevent sealant contact where it would be detrimental to sealant performance.

D. Joint Backer: Polyethylene foam rod or other compatible non-waxing, non-extruding, non-staining resilient material in dimension 25% to 50% wider than joint width as recommended by sealant manufacturer for substrates, conditions and exposures indicated.

E. Masking Tape: Non-staining, non-absorbent tape product compatible with joint sealants and adjacent joint surfaces that is suitable for masking.

F. Premolded Joint Filler: Conform to requirements of Section 03 30 00.

2.04 OTHER MATERIALS

A. Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor and approved by the sealant manufacturer as compatible, subject to the approval of the Engineer.

PART 3 - EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which Work of this Section will be performed.

1. Verify conformance with manufacturer's requirements.
2. Report unsatisfactory conditions in writing to Engineer.
3. Correct conditions detrimental to timely and proper completion of the Work.
4. Do not proceed until unsatisfactory conditions are corrected.

3.02 PREPARATION

A. Prepare surfaces to receive sealants in accordance with sealant manufacturer's instructions and recommendations except where more stringent requirements are indicated.

B. Thoroughly clean joint surfaces using cleaners approved by sealant manufacturer whether primers are required or not.

1. Remove all traces of previous sealant and joint backer by mechanical methods, such as by cutting, grinding and wire brushing, in manner not damaging to surrounding surfaces.
2. Remove paints from joint surfaces except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer.
3. Remove wax, oil, grease, dirt, film residues, temporary protective coatings and other residues by wiping with cleaner recommended for that purpose. Use clean, white, lint-free cloths and change cloths frequently.
4. Remove dust by blowing clean with oil-free, compressed air.

C. Provide joint backer material to depth required by sealant manufacturer for proper joint design.

1. Fit securely by compressing backer material 25% to 50% so no displacement occurs during tooling.
2. Avoid stretching or twisting joint backer.

D. Provide bond-breaker where indicated or recommended by sealant manufacturer, adhering strictly to the manufacturer's installation requirements.

E. Prime joint substrates where required.

1. Use and apply primer according to sealant manufacturer's recommendations.
2. Confine primers to sealant bond surfaces; do not allow spillage or migration onto adjoining surfaces.

F. Taping:

1. Use masking tape where required to prevent sealant or primer contact with adjoining surfaces that would be permanently stained or otherwise damaged by such contact or the cleaning methods required for removal.
2. Apply tape so as not to shift readily and remove tape immediately after tooling without disturbing joint seal.

G. Premolded Joint Fillers:

1. Where expansion joints having premolded joint fillers are scheduled to be sealed, provide a reservoir to accept the sealant such as by a molded breakaway joint cap or a removable block out.
2. Joint fillers that may contact the sealant should not be impregnated with oil, bitumen, non-curing polymers or similar contaminants.

3.03 INSTALLATION

A. Coordinate as required with other trades to assure proper and adequate provision in the work of those trades for interface with the Work of this Section.

B. Provide the approved sealant system where shown on the Drawings, and in strict accordance with the manufacturer's recommendations as approved by Engineer.

C. Install sealants immediately after joint preparation.

D. Mix and apply multi-component sealants in accordance with manufacturer's printed instructions.

E. Install sealants to fill joints completely from the back, without voids or entrapped air, using proven techniques, proper nozzles and sufficient force that result in sealants directly contacting and fully wetting joint surfaces.

F. Install sealants to uniform cross-sectional shapes with depths relative to joint widths that allow optimum sealant movement capability as recommended by sealant manufacturer.

G. Tool sealants in manner that forces sealant against back of joint, ensures firm, full contact at joint interfaces and leaves a finish that is smooth, uniform and free of ridges, wrinkles, sags, air pockets and embedded impurities.

1. Dry tooling is preferred; tooling liquids that are non-staining, non-damaging to adjacent surfaces and approved by sealant manufacturer may be used if necessary when care is taken to ensure that the liquid does not contact joint surfaces before the sealant.
2. Provide concave tooled joints unless otherwise indicated to provide flush tooling or recessed tooling.
3. Provide recessed tooled joints where the outer face of substrate is irregular.

H. Remove sealant from adjacent surfaces in accordance with sealant and substrate manufacturer's recommendations as work progresses.

I. Protect joint sealants from contact with contaminating substances and from damages. Cut out, remove and replace contaminated or damaged sealants, immediately, so that they are without contamination or damage at time of Substantial Completion.

END OF SECTION

DIVISION 08

OPENINGS

SECTION 08 11 13
HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. Steel doors.
2. Steel door frames.

1.02 REFERENCES

A. ANSI: American National Standards Institute

B. ASTM: American Society for Testing and Materials

C. DHI: The Door and Hardware Institute

D. SDI: Steel Door Institute

1.03 SUBMITTALS

A. Product Data: For each type of door and frame indicated, include designation, type, level and model, material description, core description, construction details, label compliance, sound and fire-resistance ratings, and finishes.

B. Shop Drawings:

1. Elevations of each door and frame design.
2. Details of doors including vertical and horizontal edge details.
3. Frame details for each frame type including dimensioned profiles.
4. Details and locations of reinforcement and preparations for hardware.
5. Details of each different wall opening condition.
6. Details of anchorages, accessories, joints, and connections.
7. Coordination of glazing frames and stops with glass and glazing requirements.

C. Schedule: Use same reference designations indicated on Drawings in preparing schedule for doors and frames.

D. American Iron and Steel Compliance Certification:

1. This project is being funded by the Clean Water State Revolving Fund that requires that all of the iron and steel products used in the project to be produced in the United States ("American Iron and Steel Requirement"). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R. 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.
2. The Manufacturer shall provide with the shop drawing submittal one signed and dated Certification Letter (a sample copies of which are provided in the Appendix). The Certification Letter shall demonstrate compliance with Section 436 of federal H.R. 3547.

D. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Steel Door and Frame Standard: Comply with ANSI A250.8, unless more stringent requirements are indicated.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver doors and frames cardboard-wrapped or crated to provide protection during transit and job storage. Provide additional protection to prevent damage to finish of factory-finished doors and frames.

B. Inspect doors and frames on delivery for damage, and notify shipper and supplier if damage is found. Minor damages may be repaired provided refinished items match new work and are acceptable to Architect. Remove and replace damaged items that cannot be repaired as directed.

C. Store doors and frames at building site under cover. Place units on minimum 4-inch high wood blocking. Avoid using nonvented plastic or canvas shelters that could create a humidity chamber. If door packaging becomes wet, remove cartons immediately. Provide minimum 1/4-inch spaces between stacked doors to permit air circulation.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Amweld Building Products, Inc.

B. Ceco Door Products.

C. Curries Company.

D. Kewanee Corporation.

E. Steelcraft.

2.02 MATERIALS

A. Hot-Rolled Steel Sheets: ASTM A568 or A569.

B. Cold-Rolled Steel Sheets: ASTM A366.

C. Metallic-Coated Steel Sheets: ASTM A 653, an A60 zinc-iron-alloy (galvannealed) coating,

2.03 DOORS

A. General: Provide doors of sizes, thicknesses, and designs indicated.

B. Interior Doors: Provide doors complying with requirements indicated below by referencing ANSI A250.8 for level and model and ANSI A250.4 for physical-endurance level:

1. Level 2 and Physical Performance Level B (Heavy Duty), Model 1 Seamless.

C. Exterior Doors: Provide doors complying with requirements indicated below by referencing ANSI 250.8 for level and model and ANSI A250.4 for physical-endurance level:

1. Level 3 and Physical Performance Level B (Extra Heavy Duty), Model 2 Seamless.

2.04 FRAMES

A. General: Provide stainless steel frames for doors, transoms, sidelights, borrowed lights, and other openings that comply with ANSI A250.8 and with details indicated for type and profile. Conceal fastenings, unless otherwise indicated.

B. Frames of 0.053-inch thick steel sheet for:

1. Door openings wider than 48 inches.
2. Level 2 steel doors.

C. Frames of 0.067-inch thick steel sheet for:

1. Door openings wider than 48 inches.
1. Level 3 steel doors.

D. Door Silencers: Except on weather-stripped frames, fabricate stops to receive three silencers on strike jambs of single-door frames and two silencers on heads of double-door frames.

E. Supports and Anchors:

1. Fabricated from not less than 0.042-inch thick, electrolytic zinc-coated or metallic-coated steel sheet.
2. Wall Anchors in Masonry Construction: 0.177-inch diameter, steel wire complying with ASTM A510 may be used in place of steel sheet.

F. Inserts, Bolts, and Fasteners: Manufacturer's standard units. Where zinc-coated items are to be built into exterior walls, comply with ASTM A153, Class C or D as applicable.

2.05 FABRICATION

A. General: Fabricate steel door and frame units to comply with ANSI A250.8 and to be rigid, neat in appearance, and free from defects including warp and buckle. Where practical, fit and assemble units in manufacturer's plant. Clearly identify work that cannot be permanently factory assembled before shipment, to assure proper assembly at Project site.

B. Exterior Construction: For exterior locations and elsewhere as indicated, fabricate doors and frames from metallic-coated steel sheet. Close top and bottom edges of doors flush as an integral part of door construction or by addition of 0.053-inch thick, metallic-coated steel channels with channel webs placed even with top and bottom edges.

C. Interior Construction: For interior locations, fabricate doors and frames from cold-rolled steel sheet or metallic-coated steel sheet.

D. Core Construction: Expanded polystyrene foam continuously bonded to steel skin.

E. Clearances for Non-Fire-Rated Doors: Not more than 1/8 inch at jambs and heads, except not more than 1/4 inch **b**etween pairs of doors. Not more than 3/4 inch at bottom.

F. Single-Acting, Door-Edge Profile: Square edge.

G. Tolerances: Comply with SDI 117.

H. Fabricate concealed stiffeners, reinforcement, edge channels, louvers, and moldings from either cold- or hot-rolled steel sheet.

I. Exposed Fasteners: Unless otherwise indicated, provide countersunk flat or oval heads for exposed screws and bolts.

J. Hardware Preparation:

1. Prepare doors and frames to receive mortised and concealed hardware according to door hardware schedule and templates provided by hardware supplier. Comply with applicable requirements in ANSI A250.6 and ANSI A115 Series specifications for door and frame preparation for hardware.
2. For concealed overhead door closers, provide space, cutouts, reinforcement, and provisions for fastening in top rail of doors or head of frames, as applicable.

K. Frame Construction:

1. Fabricate frames to shape shown.
2. Fabricate frames with mitered or coped and continuously welded corners and seamless face joints.
3. Provide temporary spreader bars.

L. Reinforce doors and frames to receive surface-applied hardware. Drilling and tapping for surface-applied hardware may be done at Project site.

M. Locate hardware as indicated on Shop Drawings or, if not indicated, according to ANSI A250.8.

P. Glazing Stops: Manufacturer's standard, formed from 0.032-inch thick steel sheet.

1. Provide nonremovable stops on outside of exterior doors and on secure side of interior doors for glass, louvers, and other panels in doors.
2. Provide screw-applied, removable, glazing stops on inside of glass, louvers, and other panels in doors.

2.06 FINISHES (GALVANIZED STEEL DOORS AND FRAMES)

A. Prime Finish: Manufacturer's standard, factory-applied coat of rust-inhibiting primer complying with ANSI A250.10 for acceptance criteria.

B. Final Finish: Conform to Section 09 96 00. Color as elected by Owner

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: Install steel doors, frames, and accessories according to Shop Drawings, manufacturer's data, and as specified.

B. Placing Frames:

1. Comply with provisions in SDI 105, unless otherwise indicated.
2. Set frames accurately in position, plumbed, aligned, and braced securely until permanent anchors are set.
3. After wall construction is completed, remove temporary braces and spreaders, leaving surfaces smooth and undamaged.
4. Except for frames located in existing walls or partitions, place frames before construction of enclosing walls and ceilings.

5. In masonry construction, provide at least three wall anchors per jamb; install adjacent to hinge location on hinge jamb and at corresponding heights on strike jamb. Acceptable anchors include masonry wire anchors and masonry T-shaped anchors.

C. Door Installation:

1. Comply with ANSI A250.8 unless otherwise indicated.
2. Fit hollow-metal doors accurately in frames, within clearances specified in ANSI A250.8.
3. Shim as necessary to comply with SDI 122 and ANSI/DHI A115.1G.

3.02 ADJUSTING AND CLEANING

A. Prime-Coat Touchup: Immediately after installation, sand smooth any rusted or damaged areas of prime coat and apply touch up of compatible air-drying primer.

B. Protection Removal: Immediately before final inspection, remove protective wrappings from doors and frames.

END OF SECTION

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SECTION 08 16 13
FIBERGLASS DOORS AND FRAMES

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Fiberglass reinforced plastic (FRP) doors.
2. FRP door frames.
3. Fire-rated fiberglass reinforced plastic (FRP) door and frame assemblies.

1.02 RFERENCES

A. ASTM: American Society for Testing and Materials

B. ANSI: American National Standards Institute

C. NFPA: National Fire Protection Association

1.03 SUBMITTALS

A. Product Data: Manufacturer's printed product data indicating characteristics of products specified and installation instructions.

B. Shop Drawings:

1. Dimensioned elevation of each type door assembly in project; indicate sizes and locations of door hardware, and lights and louvers, if specified.
2. Installation details of each type installation condition in project; indicate installation details of glazing, if specified.
3. Schedule: Indicate each door assembly in project; cross-reference to plans, elevations, and details. Use same designation indicated on Drawings.

C. Samples: Manufacturer's standard color chips.

D. Manufacturer's standard warranty documents, executed by manufacturer's representative, countersigned by Contractor.

E. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing according to NFPA 252.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing, Shipping, Handling, and Unloading: Package door assemblies in manufacturer's standard containers.

B. Store door assemblies in manufacturer's standard containers, on end, to prevent damage to face corners and edges.

1.06 WARRANTY

A. Manufacturer's Lifetime warranty against failure due to corrosion from specified environment.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS.

A. Chem-Pruf.

B. CORRIM.

C. Special-Lite.

2.02 MATERIALS

A. Fiberglass Mat: Minimum 1.5 ounces per square foot.

B. Resins: Manufacturer's formulation for fabricating units to meet specified requirements.

C. Anchors: Manufacturer's standard stainless steel expansion anchors for existing openings, and stainless steel masonry tee anchors for new construction.

D. Fasteners: Stainless steel.

E. Glazing Type specified in Section 08 81 00; factory installed.

2.03 DOOR AND FRAME COMPONENTS

A. Fiberglass Reinforced Plastic (FRP) Doors:

1. Thickness: 1-3/4 inches.
2. Thermal Insulating Value: R-value of 12.
3. Minimum glass fiber to resin ratio: 30%.
4. Core:
    a. Polyurethane foam core laminated to the interior of the panels. Core at hinges, locksets, and other hardware mounting locations shall be solid fiberglass reinforced as noted and required.
    b. Mineral core at 60 minute fire-rated FRP Doors.
5. Door Plates: Molded in one continuous piece, resin reinforced with hand-laid glass fiber mat, nominal 1/8 inch thick, minimum 15 mil gel-coated surface.
6. Door Edges: Minimum three (3) layers resin-reinforced glass fiber mat, nominal 3/8 to 1 1/2 inch thick, machine tooled.
7. Mortise for lockset, and recess for strike plate in lock stile.
8. Embed steel reinforcement for hinges in fiberglass matrix; provide for hinge leaf recesses in hinge stile.
9. Sizes: Indicated on drawings.
10. Finish: Smooth gloss or Satin surface, minimum value 88 in accordance with ASTM D523.
11. Color: as selected by ENGINEER from manufacturer’s complete line of available colors..

B. Fiberglass Frames:

1. Non-rated frames shall be one-piece solid molded fiberglass reinforced plastic, minimum 1/4 inch wall thickness.

    a. Jamb-to-head joints mitered and reinforced with FRP clips and stainless steel fasteners; conforming to ANSI A250.8 requirements for performance equivalent to 16 gauge steel frames.
    b. Frame profile: 5-3/4 inches deep, 2 inches wide face; double rabbeted with 5/8 inch high stop.
    c. Mortise for lock strike, and recess for strike plate in lock jamb.
    d. Reinforce for hinges and other indicated hardware.
    e. Sizes: Indicated on drawings.
    f. Finish: Smooth Gloss or Satin surface, with true and consistent color.
    g. Color: to match door.

2. Fire-rated frames shall be standard one piece FRP profile with integral stop; 5-3/4 inch x 2 inch equal rabbet.

    a. Jamb-to-head joints mitered and reinforced with FRP clips and stainless steel fasteners; conforming to ANSI A250.8 requirements for performance equivalent to 16 gauge steel frames.
    b. Frame profile: 5-3/4 inches deep, 2 inches wide face; equal rabbet with 5/8 inch high stop.
    c. Mortise for lock strike, and recess for strike plate in lock jamb.
    d. Reinforce for hinges and other indicated hardware.
    e. Sizes: Indicated on drawings.
    f. Finish: Smooth Gloss or Satin surface, with true and consistent color.
    g. Color: to match door.

C. Lights:

1. Stops: Pultruded fiberglass reinforced plastic stops; same color as doors.
2. Sizes: Indicated on drawings.
3. Fasteners: Stainless steel screws.
4. Glass: as specified in Section 08 81 00.

D. Frame Anchors: Types recommended by manufacturer for project conditions.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that openings are correctly prepared to receive doors and frames and are correct size and depth in accordance with shop drawings.

B. Examine conditions under which construction activities of this section are to be performed and submit written report if conditions are unacceptable.

C. Verify that glazing has been factory-installed.

3.02 INSTALLATION

A. Install door opening assemblies in accordance with shop drawings, ANSI A250.8, and manufacturer's printed installation instructions, using installation methods and materials specified in installation instructions.

B. Install of door hardware as specified in Section 08 71 00.

C. Install door hardware in accordance with manufacturer's printed instructions, using through-bolts to secure surface applied hardware.

D. Installation Tolerances: Maintain plumb and level tolerances specified in manufacturer's printed installation instructions.

E. Install Fire-Rated doors within clearances specified in NFPA 80.

F. Install fire-rated frames according to NFPA 80.

3.03 ADJUSTING

A. Adjust doors in accordance with door manufacturer's maintenance instructions to swing open and shut without binding, and to remain in place at any angle without being moved by gravitational influence.

B. Adjust door hardware to operate correctly in accordance with hardware manufacturer's maintenance instructions.

3.04 CLEANING

A. Clean surfaces of door assemblies and exposed door hardware in accordance with manufacturer's maintenance instructions.

3.05 PROTECTION

A. Protect door assemblies and door hardware from damage by subsequent construction activities until final inspection.

END OF SECTION

SECTION 08 71 00
DOOR HARDWARE

PART 1 - GENERAL

1.01 SUMMARY

A Section includes:

1. Hardware for hollow metal and fiberglass doors.

1.02 REFERENCES

A. NEMA: National Electrical Manufacture's Association

1.03 QUALITY ASSURANCE

A. Manufacturers: Companies specializing in manufacturing door hardware with minimum three years experience.

1.04 SUBMITTALS

A. Shop Drawings.

B. Product Data.

C. Submit in accordance with Section 01 33 00.

D. American Iron and Steel Compliance Certification:

1. This project is being funded by the Clean Water State Revolving Fund that requires that all of the iron and steel products used in the project to be produced in the United States ("American Iron and Steel Requirement"). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R. 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.
2. The Manufacturer shall provide with the shop drawing submittal one signed and dated Certification Letter (a sample copies of which are provided in the Appendix). The Certification Letter shall demonstrate compliance with Section 436 of federal H.R. 3547.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Package hardware items individually; label and identify package with door opening code to match hardware schedule.

B. Protect hardware from theft by cataloging and storing in secure area.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

A. Entrance Leverset, Locks, Latches.

1. Lockset manufacturers

a. Marks 95 Survivor Series, 195RAB/26D-F12, heavy duty Grade 1, dull chrome finish.
b. Corbin Russwin equivalent to above.
c. Lock Backset: 2-3/4 inches thru-bolt spacing, unless otherwise indicated.
d. Strikes: Provide manufacturer's standard strike for each lock-bolt or latch-bolt and with strike box and curved lip extended to protect frames; finished to match lock or latch.
e. Bored Locks: BHMA A156.2; Grade 1.

.

B. Lock Cylinders

1. Tumbler type, constructed from brass or bronze, stainless steel, or nickel silver.
2. High-Security Lock Cylinders: BHMA A156.30; Grade 1, interchangeable cores equivalent to Corbin Russwin 6-pin; face finished to match lockset.

C. Keying

1 Keying System: Provide blank lock cylinders and 1 key for each handset, to be keyed by the Owner.
2. Keys: Nickel silver or brass.

D. Operating Trim

1. Operating Trim: BHMA A156.6; stainless steel, unless otherwise indicated.

E. Exit Devices: Rim type x stainless steel x US 32D. Vertical rod type x stainless steel x US 32D Provide compatible F08 heavy duty exit device trim for exterior doors and compatible passage type exit device trim for interior doors.

1. Single doors:

a. ED5200 Corbin Russwin
b. 8300 Adams Rite

2. Double doors:

a. ED5400 Corbin Russwin
b. 8100 Adams Rite

F. Hinges x 4-1/2 x 4-1/2 x US 32D.

1. BB 1191 Hager
2. FBB 191 Stanley
3. BB 4101 Lawrence

G. Closers: Heavy duty parallel arm closers to resist damage from high speed wind with positive stop and hold feature. Closers shall have adjustable closing power for use on various size doors and to allow adjustment of closing speed, opening force shall initially be set at 8 pounds operating effort.

1. Sargent 351 PSH Series aluminum closer. HO - indicates hold open

H. Kick Plates – 10 inch x 2 inch LDW x US 32D x 16GA.

1. Brookline
2. Ives

3. Hiawatha
4. Rockwood

I. Thresholds - set in sealant 5 inch x 1/2 inch Clear Anodized Aluminum Thermally Broken Saddle x frame width.

1. S282A x AL	Reese
2. 252 x 3AFG x AL	Pemko
3. 8425 x AL	National Guard
4. 421S x AL	Hager

J. Door Bottom - Mill Aluminum with thermoplastic rubber.

1. DB594AU	Reese
2. 222APK	Pemko
3. 15NA	National Guard
4. 779SNMIL	Hager

K. Door Gasketing

1. Door Gasketing: BHMA A156.22; with resilient or flexible seal strips that are easily replaceable and readily available from stocks maintained by manufacturer.

L. Wall Stops x Concealed Fasteners.

1. 406/407 x convex	Ives
2. 406	Rockwood

M. Flush Bolts with Dustproof Strike long enough to pass through threshold.

1. FB458 x 26D	Ives
2. 0600 x 26D	Baldwin
3. 555 x 26D	Rockwood
4. 282D x 26D	Hager

N. Overhead Stop – Hold Open.

1. 70H x 26D	Glynn Johnson

O. Astragals x Full Height Door - Clear Anodized Aluminum with thermoplastic rubber.

1. Doors with one active leaf:

a. 158NA	National Guard
b. 355CS	Pemko

P. Electrified Strikes x stainless steel

1. 310-2 ¾	Folger Adams

2.03 FINISHES

A. Manufacturer responsible for surface preparation and priming. Finish coating of doors either in plant or field. System shall comply with Section 09 96 00, refer to Schedule. Coordinate finish color with Engineer.

B. Finishes are US 32 satin stainless steel unless otherwise noted. Closer finishes may be paint.

PART 3 - EXECUTION

3.01 INSPECTION

A. Verify that doors and frames are ready to receive work and dimensions are as indicated on shop drawings.

B. Beginning of installation means acceptance of existing conditions.

3.02 INSTALLATION

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

B. Use the templates provided by hardware item manufacturer.

3.03 HARDWARE SCHEDULE

A. Set No. 1.
1-1/2 PR Butts
1 Exit Device
1 Closer
1 Kickplate
1 Wall Stop or Floor Stop

B Set No. 2.
1-1/2 PR Butts x NRP
1 Exit Device
1 Closer x 110 degrees
1 Electrified Strike
1 Kickplate
1 Weatherstrip
1 Door Bottom
1 Threshold
1 Wall Stop or Floor Stop

C. Set No. 3.
1-1/2 PR Butts x NRP
1 Exit Device
1 Closer x 110 degrees x HO (Omit HO on D03, D06 and D08 at Structure 5)
1 Electrified Strike
1 Kickplate
1 Weatherstrip
1 Door Bottom
1 Threshold

D. Set No. 4
3 PR Butts x NRP
1 Dummy Trim Lockset
1 Exit Device
1 Electrified Strike
1 Closer x 110 degrees x HO
1 Overhead Stop
2 Flushbolts (top & bottom)
2 Kickplates

1 Weatherstripping
2 Door Bottoms
1 Threshold
1 Astragal

E. Set No. 5
3 PR Butts
1 Dummy Trim Lockset
1 Exit Device
1 Closer x 110 degrees x HO
1 Overhead Stop
2 Flushbolts (top & bottom)
2 Kickplates

END OF SECTION

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SECTION 08 81 00
GLASS GLAZING

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. Exterior and Interior doors.

1.02 REFERENCES

A. ASTM: American Society for Testing and Materials

B. ANSI: American National Standards Institute

1.03 QUALITY ASSURANCE

A. Safety Glass: Comply with ANSI Z97.1, with label on each piece.

B. Safety Glazing Materials Act.

1.04 SUBMITTALS

A. Manufacturer's Data, Glass:

1. Manufacturer's specifications and installation instructions for each type of glass required.
2. Include test data substantiating that glass complies with specified requirements.

B. Manufacturer's Data, Glazing Materials:

1. Manufacturer's specifications and installation instructions for each type of glazing sealant and compound, gasket and associated miscellaneous material. Include manufacturer's published data, or letter of certification, or certified test laboratory report indicating that each material complies with the project specifications and is suitable for the applications shown.

C. Samples, Glass:

1. Submit 3, samples of each type of glass specified.
2. Insulating glass samples need not be hermetically sealed, but edge construction shall be included.

1.05 JOB CONDITIONS

A. Weather Conditions: Do not proceed with installation of liquid sealants under adverse weather conditions, or when temperatures are below or above manufacturer's recommended limitations for installation.

1.06 GUARANTEES

A. Insulating Glass: Provide manufacturer's ten year warranty against seal separation.

PART 2 - PRODUCTS

2.01 GLASS TYPES

A. Type G1: 1 inch thick overall gray-tinted and reflective insulating glass units, with makeup of 1/4 inch gray-tinted annealed float outboard glass, 1/2 inch thick dead air space, and 1/4 inch clear polished square wire inboard glass with W-60 Building Code Marking, fire-rating 60 minutes, clear pyrolitic low-emissivity coating on #3 surface within unit. Reflective coating on the #2 surface by PPG, Solar cool gray series, LOF Eclipse series or Guardian.

B. Type G2: 1/4 inch thick, clear tempered float glass.

C. Type G3: 1 inch thick overall gray-tinted and reflective insulating glass units, with makeup of 1/4 inch gray-tinted annealed float outboard glass, 1/2 inch thick dead air space, and 1/4 inch clear annealed float inboard glass with clear pyrolitic low-emissivity coating on #3 surface within unit. Reflective coating on the #2 surface by PPG, Solar cool gray series, LOF Eclipse series or Guardian.

D. Type G4: 1-1/8 inch thick, clear 1-hour fire-rated glass with W-60 Building Code Marking.

2.02 FIRE-RATED GLAZING

A. Material: SuperLite II-XL 60 as manufactured by SAFTI FIRST, 60 minute fire-resistive with hose stream.

2.03 GLAZING SEALANTS/COMPOUNDS

A. Preformed Butyl Rubber Glazing Sealant:

1. Tape or ribbon (coiled on release paper) of polymerized butyl, of mixture of butyl and polyisobutylene, compounded with inert fillers and pigments, solvent based with minimum of 95% solids, with thread of fabric reinforcement, tack-free within 24 hours, paintable, non-staining.
2. Provide combination tape and encased continuous rubber shim, of approximately 50 durometer hardness.
3. Any caulkings or window sealants which come in contact with the insulating glass sealants are to be compatible.

2.04 GLAZING GASKETS

A. Provide glazing gaskets recommended by manufacturer.

B. Molded Neoprene Glazing Gaskets:

1. Molded or extruded neoprene gaskets or profile and hardness shown for watertight construction; comply with ASTM D2000 designation 2BC 415 to 3BC 620, black.

C. Polyvinyl Chloride Glazing Gaskets:

1. Extruded, flexible PVC gaskets of the profile and hardness shown; when not shown, for watertight construction comply with ASTM D2287.

D. Vinyl Foam Glazing Tape:

1. Closed cell, flexible, self adhesive, non-extruding, polyvinyl chloride foam tape;

recommended by manufacturer for exterior, exposed, watertight, installation of glass, with only nominal pressure in the glazing channel, comply with ASTM D1667.

2.05 MISCELLANEOUS GLAZING MATERIALS

A. Setting Blocks: Neoprene, 70-90 durometer hardness, with proven compatibility with sealants used.

B. Spacers: Neoprene 40-50 durometer hardness, with proven compatibility with sealants used.

C. Compressible Filler Rod: Closed cell or waterproof jacketed rod stock of synthetic rubber or plastic foam, proven to be compatible with sealants used, flexible and resilient, with 510 pounds per square inch compression strength for 25% deflection.

D. Cleaners, Primers and Sealers: Type recommended by sealant or gasket manufacturer.

PART 3 - EXECUTION

3.01 INSPECTION

A. Examine the framing and glazing channel surfaces, backing, removable stop design, and the conditions under which the glazing will be performed, and notify the Architect/Engineer in writing of all conditions detrimental to the proper and timely completion of the work. Do not proceed with the glazing until unsatisfactory conditions have been corrected in a manner acceptable to the Architect.

3.02 JOB REQUIREMENTS

A. Provide watertight and airtight installation of each piece of glass. Each installation shall withstand normal temperature changes, wind loading, impact loading (for operating sash and doors) without failure of any kind including loss or breakage of glass, failure of sealants or gaskets to remain watertight and airtight, deterioration of glazing materials and other defects in the work.

B. Protect glass from edge damage at all times during handling, installation and operation of the building.

C. Glazing channel dimensions shown provide for a minimum bite on the glass, minimum edge clearance and adequate sealant thicknesses, with reasonable tolerances. Be responsible for correct glass size for each opening, within the tolerances and dimensions established.

D. Comply with combined recommendations of glass manufacturer and manufacturer of sealants and other materials used in glazing, except where more stringent requirements are shown or specified, and except where manufacturer's technical representative direct otherwise.

E. Comply with "Glazing Manual" by Flat Glass Marketing Associating except as shown and specified otherwise, and except as specifically recommended otherwise by the manufacturers of the glass and glazing materials.

F. Inspect each piece of glass immediately before installation, and eliminate all which have observable edge damage or face imperfections.

G. Unify appearance of each series of lights by setting each piece to match others as nearly as possible. Inspect each piece and set with pattern, draw and bow oriented in the same direction as other pieces.

3.03 PREPARATION FOR GLAZING

A. Clean the glazing channel, or other framing members to receive glass, immediately before glazing. Remove coatings which are not firmly bonded to the substrate. Remove lacquer from metal surfaces wherever elastomeric sealants are used.

B. Apply primer or sealer to joint surfaces wherever recommended by sealant manufacturer.

3.04 GLAZING

A. Comply with ANSI Standard Z97.1-1975 Safety Glazing Code.

B. Install setting blocks of proper size at quarter points of sill rabbet. Set blocks in thin course of the heelbead compound.

C. Glazing shall be set with equal bearing for entire width.

D. Provide spacers inside and out, and of proper size and spacing, for all glass sizes larger than 50 united inches, except where gaskets are used for glazing. Provide 1/8 inch minimum bite of spacers on glass and use thickness equal to sealant width, except with sealant tape use thickness slightly less than final compressed thickness of tape.

E. Voids and Filler Rods: Prevent exudation of sealant or compound by forming voids or installing filler rods in the channels at the heel of jambs and bead (do not leave voids in the sill channels) except as otherwise indicated, depending on light size, thickness and type of glass, and complying with manufacturer's recommendations.

F. Do not attempt to cut, seam, nip or abrade glass which is chemically strengthened, tempered, or heat strengthened.

G. Force sealants into channel to eliminate voids and to ensure complete "wetting" or bond of sealant to glass and channel surfaces.

H. Tool exposed surfaces of glazing liquids and compounds to provide a substantial "wash" away from the glass. Install pressurized tapes and gaskets to protrude slightly out of the channel to eliminate dirt and moisture pockets.

I. Clean and trim excess glazing materials from the glass and stops or frames promptly after installation, and eliminate stains and discolorations.

J. Where wedge shaped gaskets are driven into one side of the channel to pressurize the sealant or gasket on the opposite side, provide adequate anchorage to ensure that gasket will not "walk" out when subjected to dynamic movement. Anchor gasket to stop with matching ribs, or by proven adhesive, including embedment of gasket tail in cured heel bead.

3.05 CURE, PROTECTION AND CLEANING

A. Cure glazing sealants and compounds in compliance with manufacturer's instructions and recommendations, to obtain high early bond strength, internal cohesive strength and surface durability.

B. Protect exterior glass from breakage immediately upon installation by attachment of crossed streamers to framing held away from glass. Do not apply markers of any type to surfaces of glass.

C. Remove and replace glass which is broken, chipped, cracked, abraded, or damaged in other

ways during the construction period, including natural causes, accidents and vandalism.

D. Maintain glass in a reasonably clean condition during construction so that it will not be damaged by corrosive action and will not contribute (by washoff) to the deterioration of glazing materials and other work.

E. Wash and polish glass on both faces not more than four days prior to acceptance of the work in each area. Comply with glass manufacturer's recommendations. Washing shall be done by professional firm.

END OF SECTION

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SECTION 08 91 19
FIXED LOUVERS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Drawings and General Requirements of contract including General and Supplementary Conditions and Division 1 specification sections apply to Work of this Section.

B. Extent of outlets and inlets work is indicated by drawings and schedules, and by requirements of this Section.

C. Types of outlets and inlets required for project include the following:

1. Louvers.

1.02 QUALITY ASSURANCE

A. ASHRAE Standards - Comply with American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE) Standard 70 "Methods Of Testing For Rating The Air Flow Performance Of Outlets and Inlets".

B. ADC Test Code - Comply with Air Diffusion Council (ADC) Equipment Test Code 1062R4 "Certification, Rating and Test Manual".

C. AMCA Standards - Comply with Air Movement and Control Association, Inc. (AMCA) Standard 500 "Test Method For Louvers, Dampers and Shutters".

D. ANSI/NFPA Standards - Comply with National Fire Protection Association (NFPA) Standard 90A "Installation of Air Conditioning and Ventilating Systems".

E. ARI Standard - Comply with Air Conditioning and Refrigeration Institute (ARI) Standard 650 - "Air Outlets and Inlets".

1.03 SUBMITTALS

A. Product Data - Submit manufacturer's data on outlets and inlets including the following:

1. Schedule of outlets and inlets indicating drawing designation, model number, size, and accessories furnished.
2. Data sheet for each type of outlet and inlet, and accessory furnished; indicating construction, finish, and mounting details.
3. Performance data for each type of outlet and inlet furnished, including pressure drop, throw and drop, and noise criteria ratings. Indicate selections on data.

B. Submit in accordance with Section 01 33 00.

C. Maintenance Data - Submit maintenance instructions, including cleaning instructions for finishes, and spare parts lists in accordance with Section 01 78 23. Include this data in maintenance manuals.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver outlets and inlets wrapped in factory-fabricated fiberboard type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.

B. Store outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.01 LOUVERS

A. Manufacturers:

1. Greenheck.
2. Carnes.
3. Ruskin.
4. Or equal.

B. Construction: Provide louvers constructed of aluminum extrusions, Alloy 6063-T5. Weld units or use stainless steel fasteners.

C. Performance: Provide weatherproof louvers of sizes as shown in schedules or on drawings. Louvers shall not exceed scheduled maximum values for free area face velocity and pressure drop at scheduled airflow rates. Intake air louvers shall not have rated minimum water entrainment velocity lower than scheduled maximum free area velocity.

D. Substrate Compatibility: Provide louvers with frame and sill styles compatible with adjacent substrate and specifically manufactured to fit into construction openings with accurate fit and adequate support for weatherproof installation. Refer to Drawings and Specifications for types of substrate which will contain each type of louver.

E. Finish: Provide louvers with 70% Kynar finish. Finish color to be Dark Bronze.

F. Accessories: Provide louvers with the following accessories as scheduled:

1. Bird Screen: Provide manufacturer's standard aluminum bird screen mounted on inside face of louver.
2. Extended sill.

PART 3 - EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which outlets and inlets are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

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

B. Check location of outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

END OF SECTION

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DIVISION 09

FINISHES

SECTION 09 26 00
GYPSUM BOARD ASSEMBLIES AND STEEL FRAMING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Interior gypsum wallboard.

1.02 DEFINITIONS

A. Gypsum Board Terminology: Refer to ASTM C 11 for definitions of terms for gypsum board assemblies not defined in this Section or in other referenced standards.

1.03 SUBMITTALS

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

B. Shop Drawings: Show locations, fabrication, and installation of control and expansion joints including plans, elevations, sections, details of components, and attachments to other units of Work.

C. American Iron and Steel Compliance Certification:

1. This project is being funded by the Clean Water State Revolving Fund that requires that all of the iron and steel products used in the project to be produced in the United States ("American Iron and Steel Requirement"). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R. 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.
2. The Manufacturer shall provide with the shop drawing submittal one signed and dated Certification Letter (a sample copies of which are provided in the Appendix). The Certification Letter shall demonstrate compliance with Section 436 of federal H.R. 3547.

D. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: For gypsum board assemblies with fire-resistance ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing and inspecting agency acceptable to authorities having jurisdiction.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in original packages, containers, or bundles bearing brand name and identification of manufacturer or supplier.

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

1.06 PROJECT/SITE CONDITIONS

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

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Steel Framing and Furring:

1. ClarkDietrich Building Systems.
2. Consolidated Systems, Inc.
3. Dale Industries, Inc. - Dale/Incor.
4. MarinoWare; Division of Ware Ind.
5. National Gypsum Company.
6. Scafco Corporation.
7. Unimast, Inc.
8. Western Metal Lath & Steel Framing Systems.

B. Gypsum Board and Related Products:

1. American Gypsum Co.
2. G-P Gypsum Corp.
3. National Gypsum.
4. United States Gypsum. Co.

2.02 STEEL PARTITION

A. Components, General:

1. Comply with ASTM C 754 for conditions indicated.
2. Steel Sheet Components: Complying with ASTM C 645 requirements for metal and with manufacturer's standard corrosion-resistant zinc coating.

B. Steel Studs and Runners (Under 20 ft. height): ASTM C 645.

1. Minimum Base Metal Thickness: 25 gauge.
2. Depth: 3-5/8 in. (92.1 mm).

C. Steel Studs and Runners (Over 20 ft. height): ASTM C.

1. Minimum Base Metal Thickness: 16 gauge.

D. Fasteners:

1. Fasteners for Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

2.03 INTERIOR GYPSUM WALLBOARD

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

B. Gypsum Wallboard: ASTM C 36.

1. Regular Type:

a. Thickness: 5/8 in., unless otherwise indicated.
b. Long Edges: Tapered and featured (rounded or beveled) for prefilling.
c. Location: As indicated on Drawings.

2.04 TRIM ACCESSORIES

A. Interior Trim: ASTM C 1047.

1. Material: Galvanized or aluminum-coated steel sheet or rolled zinc.
2. Shapes:

a. Cornerbead: Use at outside corners.
b. LC-Bead: J-shaped; exposed long flange receives joint compound; use at exposed panel edges.

2.05 JOINT TREATMENT MATERIALS

A. Comply with ASTM C 475.

B. Joint Tape:

1. Interior Gypsum Wallboard: Paper.

C. Joint Compound for Interior Gypsum Wallboard: For each coat use formulation that is compatible with other compounds applied on previous or for successive coats.

1. Prefilling: At open joints, rounded or beveled panel edge and damaged surface areas, use setting-type taping compound.
2. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use drying-type, all-purpose compound.

a. Use setting-type compound for installing paper-faced metal trim accessories.

3. Fill Coat: For second coat, use drying-type, all-purpose compound.
4. Finish Coat: For third coat, use drying-type, all-purpose compound.

2.06 ACOUSTICAL SEALANT

A. Acoustical Sealant for Exposed and Concealed Joints:

1. Manufacturers:

a. Pecora Corp.; AC-20 FTR Acoustical and Insulation Sealant.
b. United States Gypsum Co.; SHEETROCK Acoustical Sealant.

2. Nonsag, paintable, nonstaining, latex sealant complying with ASTM C 834 that effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.

2.07 AUXILIARY MATERIALS

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

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

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

C. Gypsum Board Nails: ASTM C514.

D. Fastening Adhesive (for Wood): ASTM C557.

E. Isolation Strip at Exterior Walls:

1. Asphalt-Saturated Organic Felt: ASTM D 226, Type I (No. 15 asphalt felt), nonperforated.
2. Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 in. (3.2 mm) thick, in width to suit steel stud size.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames, cast-in anchors, and structural framing, for compliance with requirements and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF STEEL FRAMING, GENERAL

A. Installation Standards: ASTM C 754, and ASTM C 840 requirements that apply to framing installation.

B. Install supplementary framing, blocking, and bracing at terminations in gypsum board assemblies to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction. Comply with details indicated and with gypsum board manufacturer's written recommendations or, if none available, with United States Gypsum's "Gypsum Construction Handbook."

3.03 INSTALLATION OF STEEL STUD PARTITIONS

A. Install tracks (runners) at floors, ceilings, and structural walls and columns where gypsum board assemblies abut other construction.

1. Where studs are installed directly against exterior walls, install foam-gasket isolation strip between studs and wall.

B. Installation Tolerance: Install each steel framing and furring member so fastening surfaces vary not more than 1/8 in. (3 mm) from the plane formed by the faces of adjacent framing.

C. Extend partition framing full height to structural supports or substrates above suspended ceilings, except where partitions are indicated to terminate at suspended ceilings. Continue framing over frames for doors and openings and frame around ducts penetrating partitions above ceiling to provide support for gypsum board.

1. Cut studs 1/2 in. (13 mm) short of full height to provide perimeter relief.

D. Install steel studs and furring at the following spacings:

1. Single-Layer Construction: 16 in. (406 mm) o.c., unless otherwise indicated.

E. Install steel studs so flanges point in the same direction and leading edge or end of each panel can be attached to open (unsupported) edges of stud flanges first.

3.04 APPLYING AND FINISHING PANELS, GENERAL

A. Gypsum Board Application and Finishing Standards: ASTM C 840 and GA-216.

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

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

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

E. Attach gypsum panels to steel studs so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.

F. Attach gypsum panels to framing provided at openings and cutouts.

G. Do not attach gypsum panels across the flat grain of wide-dimension lumber, including floor joists and headers. Float gypsum panels over these members using resilient channels, or provide control joints to counteract wood shrinkage.

H. Cover both faces of steel stud partition framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.

1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. (0.7 sq. m) in area.
2. Fit gypsum panels around ducts, pipes, and conduits.
3. Where partitions intersect open concrete coffers, concrete joists, and other structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by coffers, joists, and other structural members; allow 1/4- to 3/8-in.- (6.4- to 9.5-mm-) wide joints to install sealant.

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

J. Floating Construction: Where feasible, including where recommended in writing by manufacturer, install gypsum panels over wood framing, with floating internal corner construction.

K. Space fasteners in gypsum panels according to referenced gypsum board application and finishing standard and manufacturer's written recommendations.

1. Space screws a maximum of 12 in. (304.8 mm) o.c. for vertical applications.

L. Space fasteners in panels that are tile substrates a maximum of 8 in. (203.2 mm) o.c.

3.05 PANEL APPLICATION METHODS

A. Single-Layer Application:

1. On ceilings, apply gypsum panels before wall/partition board application to the greatest extent possible and at right angles to framing, unless otherwise indicated.
2. On partitions/walls, apply gypsum panels horizontally (perpendicular to framing), unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.

a. Stagger abutting end joints not less than one framing member in alternate courses of board.

B. Single-Layer Fastening Methods: Apply gypsum panels to supports with steel drill screws.

3.06 INSTALLING TRIM ACCESSORIES

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

B. Control Joints: Install control joints according to ASTM C 840 and in specific locations approved by ENGINEER for visual effect.

3.07 FINISHING GYPSUM BOARD ASSEMBLIES

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

B. Prefill open joints, rounded or beveled edges, and damaged surface areas.

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

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

1. Level 4: Embed tape and apply separate first, fill, and finish coats of joint compound to tape, fasteners, and trim flanges at panel surfaces that will be exposed to view, unless otherwise indicated.

END OF SECTION

SECTION 09 65 00
RESILIENT FLOORING

PART 1 - GENERAL

1.01 SUMMARY

A. Provide resilient base where shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

1.02 SUBMITTALS

A. Product data:

1. Manufacturer's information and specifications and other data needed to prove compliance with the specified requirements.
2. Samples of each item, color, and pattern available in the specified grades from the proposed manufacturers.
3. Manufacturer's recommended installation procedures.

B. Comply with Section 01 33 00.

1.03 MAINTENANCE

A. Deliver to the Owner for his use in future modifications an extra stock of approximately 10% of each color and pattern in each material installed under this Section, packaging each type of material separately, distinctly marked, and adequately protected against deterioration.

PART 2 - PRODUCTS

2.01 MATERIALS, GENERAL

A. Provide colors and patterns as selected by the Engineer from standard colors and patterns of the approved manufacturer in the specified type.

B. Adhesives:

1. Provide waterproof and stabilized type adhesive as recommended by the manufacturer of the material being installed.
2. Asphalt emulsions and other non-waterproof adhesives will not be acceptable.

C. Concrete slab primer: Provide non-staining type as required and as recommended by the manufacturer of the material being installed.

2.02 RESILIENT MATERIALS

A. Vinyl base:

1. Where noted on the Drawings, provide 4 inch vinyl topset base.

2.03 OTHER MATERIALS

A. Provide other materials, not specifically described but required for a complete and proper installation.

PART 3 - EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 PREPARATION

A. Subfloors:

1. Verify that substrate is smooth, level, at required finish elevation, and without more than 1/8 inch in 10 feet-0 inch variation from level or slopes shown on the Drawings.
2. Prior to laying materials, broom clean or vacuum the surfaces to be covered, and inspect the subfloors.

B. Priming:

1. Apply concrete slab primer if so recommended by the resilient flooring manufacturer.
2. Apply in accordance with the manufacturer's recommendations.

3.03 INSTALLATION

A. General:

1. Install materials only after finishing operations, including painting, have been completed and after permanent heating system is operating.
2. Verify that moisture content of concrete slabs, building air temperature, and relative humidity are within the limits recommended by the manufacturers of the materials used.
3. Maintain reference markers, holes, and openings that are in place or plainly marked for future cutting by repeating on the finish surface as marked in the subfloor. Use chalk or other non-permanent marking device.

B. Installing base:

1. Install base where noted on the Drawings.
2. Use factory-preformed exterior corners, and factory-preformed or job-mitered interior corners.

3.04 CLEANING AND PROTECTING

A. Remove excess adhesive and other blemishes from exposed surfaces, using neutral cleaner recommended by the manufacturer of the resilient materials.

END OF SECTION

SECTION 09 67 16
RESINOUS FLOORING

PART 1 – GENERAL

1.01 SUMMARY

A. Section includes colored aggregate-filled heavy duty epoxy flooring.

1.02 DEFINITIONS

A. Aggregate-filled epoxy flooring includes penetrating, moisture tolerant, two-component epoxy primer, a high performance, three-component mortar consisting of epoxy resin, curing agent and selected, graded aggregates blended with inorganic pigments and two-component, chemical resistant, epoxy coating.

1.03 REFERENCES

A. ASTM: American Society for Testing and Materials

B. ICRI: International Concrete Repair Institute

C. ISO: International Organization for Standardization

D. SSPC: Society for Protective Coatings

1.04 SUBMITTALS

A. Product Data: Submit manufacturer's technical data, installation instructions, and general recommendations for each resinous flooring material required. Include certification indicating compliance of materials with requirements.

B. Samples: Submit, for verification purposes, 4-inch square samples of each type of resinous flooring required, applied to a rigid backing, in color and finish indicated.

1. For initial selection of colors and finishes, submit manufacturer's color charts showing full range of colors and finishes available.

1.05 QUALITY ASSURANCE

A. Single Source Responsibility: Obtain primary resinous flooring materials including primers, resins, hardening agents, finish of sealing coats from a single manufacturer with not less than ten years of successful experience in manufacturing and installing principal materials described in this section. Contractor shall have completed at least five projects of similar size and complexity. Provide secondary materials of type and from source recommended by manufacturer of primary materials.

B. Pre-Installation Conference

1. General Contractor shall arrange a meeting not less than thirty days prior to starting work.
2. Attendance

a. Contractor
b. Architect/owner
c. Manufacturer/Installer's representative

C. ISO 9002: All materials, including primers, resins, curing agents, finish coats, aggregates, and sealants are manufactured and tested under an ISO 9002 registered quality system.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Material shall be delivered to job site and checked by flooring contractor for completeness and shipping damage prior to job start.

B. All materials used shall be factory pre-weighed and pre-packaged in single, easy to manage batches to eliminate on site mixing errors. No on site weighing or volumetric measurements allowed.

C. Material shall be stored in a dry, enclosed area protected from exposure to moisture. Temperature of storage area shall be maintained between 60 and 85°F.

1.06 PROJECT / SITE CONDITIONS

A. Concrete substrate shall be properly cured for a minimum of 30 days. A vapor barrier must be present for concrete subfloors on or below grade. Otherwise, an osmotic pressure resistant grout must be installed prior to the resinous flooring.

B. Utilities, including electric, water, heat (air temperature between 60 and 85°F) and finished lighting to be supplied by Contractor.

C. Job area to be free of other trades during, and for a period of 24 hours, after floor installation.

D. Protection of finished floor from damage by subsequent trades shall be the responsibility of the Contractor.

1.07 WARRANTY

A. Manufacturer shall furnish a single, written warranty covering both material and workmanship for a period of one full year from date of installation.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Stonhard Stonshield HRI top coated with Stonkote CE4.

A. Florock FloroBuild top coated with Floropoxy 4805.

B. Or Equal.

2.02 AGGREGATE-FILLED EPOXY FLOORING

A. Nominal 3/16 inch thick system comprised of a penetrating, moisture tolerant, two-component epoxy primer; a high performance, three-component mortar base consisting of epoxy resin, curing agent and selected, graded aggregates blended with inorganic pigments; and a two-component, 100% solids, epoxy resin, undercoat; pigmented quartz aggregate broadcast media; and two-component, 100% solids, UV stable clear sealer..

1. System Components: Manufacturer's standard components that are compatible with each other and as follows:

2. Primer:

    a. Material Basis: Stonhard Standard Primer
    b. Resin: Epoxy
    c. Formulation Description: (2) two component, 100 percent solids.
    d. Application Method: Squeegee and roller.
    e. Number of Coats: (1) one.

3. Mortar Base:

    a. Material design basis: Stonshield HRI Base
    b. Resin: Epoxy.
    c. Formulation Description: (3) three component, 100 percent solids.
    d. Application Method: Metal Trowel.
        1) Thickness of Coats: nominal 1/8" (inch).
        2) Number of Coats: One.
    e. Aggregates: Pigmented Blended aggregate.

4. Undercoat:

    a. Material Basis: Stonshield undercoat.
    b. Resin: Epoxy
    c. Formulation Description: (2) two-component, 100% solids, UV Stable.
    d. Type: Clear.
    e. Finish: Gloss.
    f. Number of Coats: one.

5. Broadcast Media:

    a. Material Basis: Stonshield quartz aggregate
    b. Type: pigmented.
    c. Finish: standard.
    d. Number of Coats: one.
    e. Pattern: Tweed.

6. Sealer:

    a. Material Basis: Stonkote CE4.
    b. Resin: Epoxy
    c. Formulation Description: (2) two-component, 100% solids, UV Stable.
    d. Type: Clear.
    e. Finish: Gloss.
    f. Number of Coats: one.
    g. Texture level: Standard or medium.

B. System Physical Properties: Provide resinous flooring system with the following minimum physical property requirements when tested according to test methods indicated:

1. Compressive Strength: 10,000 psi after 7 days per ASTM C579
2. Tensile Strength: 2,000 psi per ASTM C307
3. Flexural Strength: 4,300 psi per ASTM C580
4. Flexural Modulus of Elasticity: 2.0 x 10^6 psi per ASTM C580
5. Hardness: 85 to 90 per ASTM D2240, Shore D
6. Impact Resistance: > 160 in./lbs. per ASTM D2794

7. Abrasion Resistance: 0.06 gm max. weight loss per ASTM D 4060, CS-17
8. Flammability: Class 1 per ASTM E-648.
9. Thermal Coefficient of Linear Expansion: 1.3 x 10^{-5} in./in. ^{o}F
10. Water Absorption: 0.1% per ASTM C 413
11. VOC Content per ASTM D2369:
    a. Stonshield HRI Base – 40 g/l
    b. Stonshield Undercoat – 34 g/l
    c. Stonkote CE4 – 34 g/l
12. Cure Rate @ 77^{o}F/25^{o}C: 12 hours foot traffic, 24 hours normal operations

2.03 COLORS

A. Colors: As selected by Engineer from manufacturer's standard colors.

2.04 JOINT SEALANT MATERIALS

A. Type produced by manufacturer of resinous flooring system for type of service and joint condition indicated.

PART 3 – EXECUTION

3.01 PREPARATION

A. Substrate: Concrete must be at least 28 days old and shall pass a dryness test in accordance to ASTM D4263 Test Method for Indicating Moisture by the Plastic Sheet Method, before coating is applied. Should moisture be detected, perform "Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride." (Reference ASTM F1869) Moisture content not to exceed three pounds per 1,000 square feet in a 24-hour period. Shot-blast or mechanically abrade in accordance with SSPC-SP13 Surface Preparation of Concrete to remove laitance, curing compounds, hardeners, sealers and other contaminants and to provide surface profile. Surface profile to be in accordance with ICRI CSP5-9. Large voids, bugholes and other cavities should be filled with recommended filler or surfacer. Surface must be clean, dry and free of oil, grease and other contaminants. Substrate and ambient temperature shall be between 55ºF-90ºF.

3.02 APPLICATION

A. General: Apply each component of resinous flooring system in compliance with manufacturer's directions to produce a uniform monolithic wearing surface of thickness indicated, uninterrupted except at divider strips, sawn joints or other types of joints (if any), indicated or required.

B. Primer: Mix and apply primer over properly prepared substrate with strict adherence to manufacturer's installation procedures and coverage rates. Coordinate timing of primer application with application of troweled mortar to ensure optimum adhesion between resinous flooring materials and substrate.

C. Troweled Mortar: Mix mortar material according to manufacturer's recommended procedures. Uniformly spread mortar over substrate using manufacturer's specially designed screed box adjusted to manufacturer's recommended height. Hand trowel apply mixed material over freshly primed substrate using stainless steel finishing trowels.

D. Coating: Remove any surface imperfections by lightly abrading and vacuuming the floor surface. Mix coating to manufacturer's recommended procedures. Squeegee apply and backroll with strict adherence to manufacturer's installation procedures and coverage rates.

3.03 FIELD QUALITY CONTROL

A. The right is reserved to invoke the following material testing procedure at any time, and any number of times during period of flooring application.

B. The Owner will engage service of an independent testing laboratory to sample materials being used on the job site. Samples of material will be taken, identified and sealed, and certified in presence of Contractor.

C. Testing laboratory will perform tests for any of characteristics specified, using applicable testing procedures referenced herein, or if none referenced, in manufacturer's product data.

D. If test results show materials being used do not comply with specified requirements, Contractor may be directed by Owner to stop work; remove non-complying materials; pay for testing; reapply flooring materials to properly prepared surfaces which had previously been coated with unacceptable materials.

3.04 CURING, PROTECTION AND CLEANING

A. Cure resinous flooring materials in compliance with manufacturer's directions, taking care to prevent contamination during stages of application and prior to completion of curing process. Close area of application for minimum of 24 hours.

B. Protect resinous flooring materials from damage and wear during construction operation. Where temporary covering is required for this purpose, comply with manufacturer's recommendations for protective materials and method of application. Contractor is responsible for protection and cleaning of surfaces after final coats.

C. Cleaning: Remove temporary covering and clean resinous flooring just prior to final inspection. Use cleaning materials and procedures recommended by resinous flooring manufacturer.

END OF SECTION

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SECTION 09 96 00
HIGH-PERFORMANCE COATINGS

PART 1 – GENERAL

1.01 SUMMARY

A. Coating of surfaces as noted on the Drawings and as specified herein, including:

1. New and existing surfaces described in Finish Schedules and notes on Drawings.
2. Interior masonry wall surfaces.
3. Exposed underside of precast concrete roof and floor members.
4. Exposed interior and exterior ferrous metal, ductile iron, or cast iron piping, regardless of factory-applied finish.
5. Exposed interior and exterior structural steel surfaces.
6. Exterior and interior equipment, pumps, valves, motors, etc. and all appurtenances.
7. Color-coded equipment and piping above ceilings.
8. Concrete tank and channel surfaces only where noted on drawings.
9. Copper piping and galvanized steel piping and conduit mounted to coated surfaces.
10. Exposed interior and exterior galvanized steel conduit and supports.
11. Steel doors and frames.
12. Existing surfaces remodeled or damaged during construction which presently have a finish. Refinish surrounding areas as required so touch-up not visible from 6 feet away.
13. Existing surfaces exposed by removals where adjacent surface has a finish. Finish areas as required so touch-up not visible from 6 ft away.
14. Touchup and finish coatings on Owner-furnished equipment, material, and appurtenant items.
15. New mag meters.

B. Labeling and directional arrows on piping, equipment, valves, and ducts whether coated or not coated is specified in Section 40 05 05.

C. Do not coat the following unless specifically noted otherwise:

1. Factory-finished electrical motor control center (MCC), main instrument panels (MIP), flow indicators, and related equipment.
2. Moving parts of operating units, electrical parts, linkages, sensing devices, and motor shafts.
3. Buried equipment and piping.
4. Surfaces above ceilings.
5. Factory-finished trim.
6. Stainless steel, chrome plate, copper, bronze, galvanized surfaces, and similar finished materials.
7. Aluminum ductwork or aluminum faced insulation.
8. Aluminum louvers and trim.
9. Concrete tanks.
10. Plastic and FRP piping, equipment, and ductwork.

D. Do not coat over any code-required labels such as UL and Factory Mutual, or any equipment identification, performance rating, name, or nomenclature plates.

E. Contractor shall take precautions to not coat over ground rings and ground straps on mag meters scheduled for coatings.

F. Equipment manufacturers are responsible for surface preparation and coating of equipment, motors, and appurtenances. Equipment to be coated and coating system is identified in the equipment specification sections.

1.02 DEFINITIONS

A. Definitions as used in Finish Schedule shown on Drawings and Coating Schedule included herein.

1. Coatings: Paint or heavy duty finishes for use on surfaces subject to interior and exterior exposure, submergence, high moisture, splash, or chemical environment, including primers, sealers, fillers, and intermediate and finished coats.
2. Submerged NP: Surfaces submerged in non-potable liquid plus 1 foot-6 inches above high liquid level.
3. First Coat: Field primer, factory primer, or shop primer. When only one coat is required, first coat is the finished coat.
4. Second, Third, or Intermediate Coats: Successive finished coats applied over first coat.
5. DFT: Dry film thickness (mils/coat).
6. sfpg: Square feet per gallon (per coat).

1.03 SUBMITTALS

A. Product Data:

1. Manufacturer's literature including application recommendations and generic makeup for each coating scheduled.
2. Factory or shop-applied primer manufacturer's literature including application recommendations and generic makeup shall be submitted with all material and equipment submittals. All primers shall conform to the requirements of this Section.

B. Miscellaneous:

1. Schedules:

a. Schedule of proposed coating systems within 60 days after Notice to Proceed.
b. Schedule of proposed coating systems shall contain all information as indicated in Coating Schedule included herein.

C. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements:

1. All coatings shall conform to OSHA requirements for allowable exposure to lead and other hazardous substances.

B. Applicator Qualifications:

1. Engage an experienced applicator who has successfully completed coating system applications similar in material and extent to those indicated.

C. Single-Source Responsibility:

1. Provide coating material produced by same manufacturer for each system.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Materials shall be delivered to site in original containers with labels intact and seals unbroken.

B. Protect and heat or cool material storage location to maintain temperature ranges recommended by coating manufacturers, but not less than 55°F.

C. Avoid danger of fire. Oily rags and waste must be removed from buildings each night or kept in appropriate metal containers. Provide fire extinguishers of type recommended by coating manufacturer's in areas of storage and where finishing is occurring. Allow no smoking or open containers of solvent.

D. Empty containers shall have labels canceled and clearly marked as to use.

1.06 PROJECT / SITE CONDITIONS

A. Environmental Requirements:

1. Dry-heat and ventilate areas to obtain conditions recommended by coating manufacturer.
2. Relative humidity conditions as specified by coating manufacturer shall be adhered to.
3. No unprotected, unheated exterior coating shall be undertaken when cold, damp, foggy, or rainy weather appears probable, nor when the temperature of the substrate is below 55°F, unless approved in writing by coating manufacturer.
4. Maintain manufacturer's environmental requirements until coating is fully cured.
5. Apply no coating in areas where dust is being generated.
6. Testing and disposal of any waste and coating shall be the responsibility of the Contractor.

B. Protection:

1. Drop cloths shall be provided in all areas where coating is done to fully protect other surfaces.
2. Remove hardware, accessories, plates, lighting fixtures, and similar items or provide protection by masking. Upon completion, replace items or remove protection and clean.

C. It is the intent of this Section that all ferrous metal items scheduled for coating be shop-primed. If items are not shop-primed, surfaces shall be prepared and coated in the field as specified.

D. Upon Substantial Completion, remaining unused material will become property of Owner. Seal material as required for storage, mark contents with color, type, location, and shelf life, and store on Site where required by Owner. Provide minimum of two gallons of each system component and color used.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Tnemec.

B. Sherwin-Williams

2.02 MATERIALS

A. Coatings shall meet surface burning characteristics as required by code and established by ASTM E84.

B. Coating products listed in the Coating Schedule, are set as a standard of quality. Coatings of substitute manufacturers shall meet or exceed the characteristics of the products listed as established by the flowing ASTM standards; B117, C307, C413, C579, C580, C868, D870, D1014, D1653, D2047, D2240, D2370, D2794, D3363, D4060, D4141, D4541, D4585, D4587, and G85.

C. If the Contractor wishes to offer a substitute to the products specified, the request for a substitute shall conform to the requirements of Section 01 61 00.

D. The Contractor and top coat coating manufacturer shall verify the compatibility of their products with the various primers used on shop primed materials and equipment.

2.03 COLORS

A. Color shall be formed of pigments free of lead, lead compounds, or other materials which might be affected by presence of hydrogen sulfide or other gases likely to be present at Site.

B. Colors shall be as selected by Owner. System color-coding shall be as specified in Section 40 05 05.

C. All pipe shall be painted with ANSI 70 grey color. Coiling plastic banding shall be used for pipe labels to identify pipe contents.

D. Coat access doors of electrical distribution panels and grilles to match color of adjacent wall or ceiling surfaces.

E. In areas scheduled for finishing, coat exposed piping, conduit, and ducts to match color of adjacent or near surfaces, except for color-coding.

F. In areas where existing surfaces are finished, coat new exposed piping, conduit, and ducts to match color of adjacent or near surfaces, except for color-coding.

G. Equipment Colors:

1. Equipment includes pumps, blowers, valves, flow meters, etc, and associated motors, structural supports, hangers, and attached portions of electrical conduit, and other associated components.
2. Color of non-submerged equipment, including equipment with a manufacturer-applied finish coat, shall be same color as piping equipment serves; see Section 40 05 05.
3. Color of submerged equipment can be manufacturer's standard color.

2.04 THINNING, MIXING, AND TINTING

A. Where thinning is necessary, only the products of the manufacturer furnishing the coating will be allowed. All such thinning shall be done in strict accordance with coating manufacturer's recommendations.

B. Mix in accordance with manufacturer's recommendations.

C. Each coat shall be slightly darker than preceding coat, unless otherwise noted. Tint undercoats similar to finish coat.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine the areas and conditions under which Work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work.

B. Materials removed and replaced to correct defects due to Work placed on unsuitable surfaces shall be at Contractor's expense.

3.02 SURFACE PREPARATION

A. General:

1. All surfaces to be coated shall be prepared as specified herein and in accordance with coating manufacturer's recommendations. The object shall be to obtain a uniform, clean, and dry surface.
2. Quality of surface preparation described herein is considered a minimum. If coating manufacturer requires a higher degree of preparation, comply with coating manufacturer's recommendations.
3. Where surface dryness is questioned, test with dampness indicating instrument. Do not apply coatings over surfaces where moisture content exceeds that permitted by coating manufacturer.
4. Shop primed surfaces shall be scarified before applying top coats. Conform to top coat manufacturers recommendations.
5. If recoat time between application of primer and second coat or between top coats is exceeded, scarify surface before applying coatings. Conform to top coat manufacturers recommendations.
6. Workmanship for surface preparation shall conform to the following SSPC specifications:

   a. Solvent Clean: SP-1.
   b. Hand Tool Cleaning: SP-2.
   c. Power Tool Cleaning: SP-3.
   d. White Metal Blast Cleaning: SP-5.
   e. Commercial Blast Cleaning: SP-6.
   f. Brush-Off Blast Cleaning: SP-7.
   g. Pickling: SP-8.
   h. Near-White Blast Cleaning: SP-10.
   i. Power Tool Cleaning to Bare Metal: SP-11.
   j. Surface Preparation by Water Jetting: SP-12.

B. Ferrous Metal:

1. Ferrous metal primed in the shop shall have all rust, dust, scale, and other foreign substances removed by abrasive cleaning conforming to SSPC SP-10. Cleaned metal shall be primed or pretreated immediately after cleaning to prevent new rusting.
2. Ferrous metal not primed in the shop shall be abrasive blast cleaned in the field prior to application of primer, pretreatment, or coating. Blast cleaning shall conform to SSPC SP-10 for submerged service. Blast cleaning shall conform to SSPC SP-6 for non-submerged service.
3. Prior to finish coating, primed areas that are damaged shall be cleaned and spot primed.

C. Concrete:

1. Concrete must be at least 28 days old and shall pass the overnight visqueen test for dryness before applying coating.

2. Repair surface defects / voids as recommended by coating manufacturer.
3. Concrete surfaces, including precast concrete, to be coated shall be cleaned of all form oil, curing compound, laitenance, and other foreign substances.
4. Surfaces shall be brush-off abrasive blast cleaned in order to prepare the surface for adherence of the coating system. Acid etching will be allowed only where brush blasting is impractical. Resulting surface shall have a toothed or grainy texture.
5. After cleaning, surfaces shall be washed and all dust, sand, and loose particles removed by vacuuming. If Contractor elects to blow off the surfaces with air, it shall be oil-free air and the method shall conform to OSHA requirements.

D. Galvanized Metal:

1. Where galvanized metal items are not submerged or buried, they shall be abrasive sweep blast cleaned and then solvent cleaned in accordance with SSPC SP-1.

E. Copper:

1. Where copper piping is not submergerd or buried, it shall be lightly sanded and then solvent cleaned in accordance with SSPC SP-1.

F. Plastic and FRP:

1. Where scheduled to coated, plastic and FRP shall be lightly sanded and then solvent cleaned in accordance with SSPC SP-1.

G. Aluminum:

1. Where scheduled to coated, aluminum shall be lightly sanded and then solvent cleaned in accordance with SSPC SP-1.

H. Masonry:

1. Remove loose grit and mortar.
2. Remove grease, oil, dirt, salts, or other chemicals, or other foreign substances by solvent, detergent, or other suitable cleaning methods.

I. Wood:

1. Wood surfaces shall be thoroughly cleaned and free of all foreign substances. Cracks, nail holes, and other defects shall be properly filled and sanded.
2. Wood trim shall be sanded to a fine finish and wiped clean of dust.

J. Gypsum Board:

1. Fill scratches, nicks, and uneven areas with spackling compound and sand smooth flush with adjacent surface.

K. Plaster:

1. Cut scratches, cracks, and abrasions from surfaces as required, fill with plaster of paris, spackling compound, or other approved material, sand smooth flush with adjacent surface, and seal before applying primer.
2. Give suction spots a second coat of primer before applying finish coat.

L. Existing Surfaces:

1. Remove and replace or mask attachments if attachments are not to be coated.
2. Remove surface contamination such as oil, grease, loose or defective coatings, mill scale, dirt, rust, mold, mildew, mortar, efflorescence, and sealers to assure sound bonding to tightly adhered old coatings. Glossy surfaces of old coatings shall be cleaned and dulled before overcoating.
3. Sand surfaces and feather edges where chips have occurred.
4. Cut out and fill cracks or other defects to match adjacent surface.
5. Exact nature of existing coatings is not known. Check compatibility of new coating by application to small area prior to starting coating. If lifting or other problems occur, notify Engineer for direction.
6. Comply with new coating manufacturer's recommendations for preparation of previously coated surfaces.
7. Prepare surfaces subject to submerged service as specified for new surfaces.

3.03 APPLICATION

A. Surfaces shall be dry at time of application.

B. The minimum surface temperature shall be 55°F and rising.

C. Apply in strict accordance with manufacturer's recommendations by brush, roller, spray, or other application method. The number of coats and thickness required is the same regardless of application method.

D. Each coat shall be allowed to dry in accordance with manufacturer's requirements. Drying time shall be construed to mean "under normal conditions". Where conditions other than normal exist, because of weather or because of confined space, longer times will be necessary. Units shall not be put in service until coatings are thoroughly dry and cured.

E. Surfaces to be coated that will be inaccessible in the completed work shall receive the final coat before enclosure.

F. Coatings shall be applied to provide an opaque, smooth surface of uniform finish, color, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, or other surface imperfections will not be acceptable. Areas cut-in by brush prior to rolling shall have uniform appearance in comparison with adjoining surfaces.

G. Make edges of coating adjoining other materials or colors sharp and clean without overlapping.

H. Concrete block walls shall be back-rolled in conjunction with application of sprayed prime coat.

I. Crevices and other hard-to-apply areas shall be back-rolled/back-brushed in conjunction with application of field applied prime coat or intermediate coat. This includes, but is not limited to: between pipe flanges, pipe flange/barrel joints, equipment fittings, and other narrow openings.

J. Finish edges of doors as specified for faces. Apply first finish coat on edges before fitting. After doors fitted and hung apply second finish coat.

K. Manufacturer-Applied Coatings:

1. Repair abraded areas on factory-finished items in accordance with equipment manufacturer's recommendations.
2. Blend repaired areas into original finish.

3.04 FIELD QUALITY CONTROL

A. Examination of Work on Site by coating manufacturer's representative shall be preformed when requested by Engineer.

B. Sampling of Materials:

1. Engineer reserves the right to select unopened containers of materials furnished for the Project and have the materials tested at an independent laboratory. Owner will pay for first tests.
2. Retests of rejected materials and tests of replacement materials shall be paid for by Contractor.
3. Remainder of contents of containers not required for testing will be returned to Contractor.

C. Coverage:

1. Before beginning Work, finish one complete room, space, surface, and item of each color scheme required, showing selected colors, finished texture, material, and workmanship. After approval, sample room, space, surface, and item shall serve as standard for similar Work.
2. If coverage is not acceptable to Engineer, Engineer reserves the right to require additional application of coating at no extra cost to Owner.

D. Work at Site, where coat of material is to be applied, shall be observed by Engineer after surface has been prepared and before application of specified prime coat and each succeeding coat, otherwise no credit for applied coat will be given and Contractor automatically assumes responsibility to recoat Work in question. Surfaces coated without such observation shall be abrasive blast cleaned, reprepared, and recoated at no addition cost to Owner. Notify Engineer when surface preparation complete, coat applied, and when ready for inspection to comply with above.

3.05 FINAL TOUCH-UP AND CLEANING

A. Prior to Substantial completion, examine coated surfaces and retouch or refinish surfaces to leave in condition acceptable to Engineer.

B. Remove masking, coatings, and other material from floors, glass, and other surfaces not scheduled to be coated.

3.06 COATING SCHEDULE

A. Scheduled thickness or coverage rate is minimum as recommended by manufacturer. Manufacturer's recommendations shall be followed, but in no case shall the thickness or coverage rate be less than scheduled.

B. Coatings shall conform to the following schedule and coating manufacturer's recommendations. Examples of surfaces to be coated may not be all inclusive.

COATINGS SCHEDULE

System No.	Generic Type	Application	Tnemec	Sherwin-Williams
1	Polyamidoamine Epoxy	Interior Concrete Block Walls / Satin	First Coat – Series N69 @ 105 sfpg, sprayed and backrolled Second Coat – Series N69 @ 150 sfpg Third Coat – Series N69 @ 165 sfpg	First Coat – Macropoxy 646 @ 90 sfpg, sprayed and backrolled Second Coat – Macropoxy 646 @ 130 sfpg Third Coat – Macropoxy 646 @ 140 sfpg
3	Polyamidoamine Epoxy	Interior Concrete Floors / Satin	First Coat – Series N69, thinned 10%, @ 115 sfpg, hand broadcast anti-skid aggregate while still wet Second Coat – Series N69 @ 190 sfpg	First Coat – Macropoxy 646, thinned 10%, @ 100 sfpg, hand broadcast anti-skid aggregate while still wet Second Coat – Macropoxy 646 @ 160 sfpg
4	Polyamidoamine Epoxy	Interior Concrete Walls / Satin	First Coat – Series N69 @ 115 sfpg Second Coat – Series N69 @ 190 sfpg	First Coat – Macropoxy 646 @ 100 sfpg Second Coat – Macropoxy 646 @ 160 sfpg
5	Polyamidoamine Epoxy	Exposed Concrete Ceilings / Satin	First Coat – Series N69, thinned 10%, @ 115 sfpg Second Coat – Series N69 @ 190 sfpg	First Coat – Macropoxy 646, thinned 10%, @ 100 sfpg Second Coat – Macropoxy 646 @ 160 sfpg
6	Epoxy Modified Mortar - Polyamidoamine Epoxy	Concrete / Submerged NP / Satin	Filler – Series 218 as needed to fill voids and bugholes First Coat – Series N69, thinned 10%, @ 115 sfpg Second Coat – Series N69 @ 190 sfpg Third Coat – Series N69 @ 190 sfpg	Filler –Dura-Plate 2300 as needed to fill voids and bugholes First Coat – DuraPlate 235, thinned 10%, @ 100 sfpg Second Coat – DuraPlate 235 @ 160 sfpg Third Coat – DuraPlate 235 @ 160 sfpg
6 ALT	Epoxy Modified Mortar - Glass Flake Reinforced Amine Epoxy	Concrete / Submerged NP		Filler – Dura-Plate 2300 as needed to fill voids and bugholes First Coat –SherGlass FF@ 10 mils DFT Second Coat – SherGlass FF @ 10 mils DFT
7	Modified Aromatic Polyurethane - Polyamidoamine Epoxy	Ferrous Metal, Cast Iron, Ductile Iron / Submerged NP / Satin	First Coat – Series 1 @ 3 mils DFT, touch-up primer prior to second coat Second Coat – Series N69 @ 5 mils DFT Third Coat – Series N69 @ 5 mils DFT	First Coat – Corothane I Mio-Zinc @ 3 mils DFT, touch-up primer prior to second coat Second Coat – DuraPlate 235 @ 5 mils DFT Third Coat – DuraPlate 235 @ 5 mils DFT
8	Modified Aromatic Polyurethane - Polyamidoamine Epoxy	Ferrous Metal, Cast Iron, Ductile Iron / Interior Non-Submerged / Satin	First Coat – Series 1 @ 3 mils DFT, touch-up primer prior to second coat Second Coat – Series N69 @ 5 mils DFT Third Coat – Series N69 @ 5 mils DFT	First Coat – Corothane I Mio-Zinc @ 3 mils DFT, touch-up primer prior to second coat Second Coat – Macropoxy 646 @ 5 mils DFT Third Coat – Macropoxy 646 @ 5 mils DFT

9	Modified Aromatic Polyurethane - Polyamidoamine Epoxy – Aliphatic Acrylic Polyurethane	Ferrous Metal, Cast Iron, Ductile Iron / Exterior Non-Submerged / Gloss	First Coat – Series 1 @ 3 mils DFT, touch-up primer prior to second coat Second Coat – Series N69 @ 5 mils DFT Third Coat – Series 1094 @ 3 mils DFT	First Coat – Corothane I Mio-Zinc @ 3 mils DFT, touch-up primer prior to second coat Second Coat – Macropoxy 646 @ 5 mils DFT Third Coat – Hi-Solids Polyurethane Gloss @ 3 mils DFT
10	Polyamide Epoxy – Polyamidoamine Epoxy	Doors, Frames, Motors and other Equipment with Non-Epoxy Primer / Interior / Satin	Lightly Hand Sand Solvent Clean SP-1 First Coat – Series 27-1255 Beige @ 3 mils DFT Second Coat – Series N69 @ 5 mils DFT	Lightly Hand Sand Solvent Clean SP-1 First Coat – Recoatable Epoxy Primer Tan @ 3 mils DFT Second Coat – Macropoxy 646 @ 5 mils DFT
11	Polyamide Epoxy – Aliphatic Acrylic Polyurethane	Doors, Frames, Motors, Mag Meters and other Equipment with Non-Epoxy Primer / Exterior / Gloss	Lightly Hand Sand / Uniformly Abrade to Degloss Solvent Clean SP-1 First Coat – Series 27-1255 Beige @ 3 mils DFT Second Coat – Series 1094 @ 3 mils DFT	Lightly Hand Sand Solvent Clean SP-1 First Coat – Recoatable Epoxy Primer Tan @ 3 mils DFT Second Coat – Hi-Solids Polyurethane Gloss @ 3 mils DFT
12	Polyamidoamine Epoxy	Galvanized Metal, Copper, PVC / Non-Submerged / Interior / Satin	First Coat – Series N69-1255 Beige @ 2 mils DFT, touch-up primer prior to second coat Second Coat – Series N69 @ 3 mils DFT Third Coat – Series N69 @ 3 mils DFT	First Coat – Macropoxy 646 – SW4004 @ 2 mils DFT, touch-up primer prior to second coat Second Coat – Macropoxy 646 @ 3 mils DFT Third Coat – Macropoxy 646 @ 3 mils DFT
13	Polyamidoamine Epoxy – Aliphatic Acrylic Polyurethane	Galvanized Metal, Copper, PVC / Non-Submerged / Exterior / Gloss	First Coat – Series N69-1255 Beige @ 2 mils DFT, touch-up primer prior to second coat Second Coat – Series N69 @ 3 mils DFT Third Coat – Series 1094 @ 3 mils DFT	First Coat – Macropoxy 646 SW4004 @ 2 mils DFT, touch-up primer prior to second coat Second Coat – Macropoxy 646 @ 3 mils DFT Third Coat – Hi-Solids Polyurethane Gloss @ 3 mils DFT
20	Polyamide Epoxy Coal Tar	Dissimilar Metal Protection / Semi-Gloss	Scarify the Surface, SP-1 First Coat – Series 46H-413 @ 20 mils DFT	Scarify the Surface, SP-1 First Coat – HiMil Sher-Tar @ 20 mils DFT
28	Aggregate-Filled Modified Polyamine Epoxy	Interior Concrete Floors / Gloss	First Coat – Series 237, @ 80 sfpg, squeegee and backrolled, hand broadcast to rejection anti-skid 30 mesh flint shot aggregate while still wet, sweep off excess after dry Second Coat – Series 280 @ 100 sfpg	First Coat – Corobond 100, @ 270 sfpg, squeegee and backrolled, hand broadcast to rejection anti-skid 30 mesh flint shot aggregate while still wet, sweep off excess after dry Second Coat – Cor-Cote HP @ 100 sfpg

Foot Notes:

1. Where an Alternative System No. (ALT) is noted the Contractor may substitute the ALT system when approved by the Engineer. If the ALT system is used, it shall be used for all work covered by that system.
2. Series N69 may be substituted for Series 1.

END OF SECTION

DIVISION 10

SPECIALTIES

SECTION 10 14 00
SIGNAGE

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Engraved plastic laminate door signs.

B. Refer to Division 26 sections for identification requirements of electrical and instrumentation work, not work of this section.

C. Refer to Division 40 for identification requirements of piping and equipment, not work of this section.

1.02 DEFINITIONS

A. ANSI: American National Standards Institute

B. FS: Federal Specification.

1.03 SUBMITTALS

A. Provide product data, sign elevations and sign schedule.

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 yrs.

B. Regulatory Requirements:

1. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Allen Systems, Inc.

B. Brady (W.H.) Company, Signmark Division.

C. Marking Services, Inc.

D. Industrial Safety Supply Company, Inc.

E. Seton Name Plate Corporation.

2.02 LETTERING AND GRAPHICS

A. The wording on the signs shall match the room name shown on the drawings.

B. Coordinate names, abbreviations, and other designations with OWNER.

2.03 ENGRAVED PLASTIC LAMINATE SIGNS

A. Engraving stock melamine plastic laminate complying with FS L-P-387A(1) in sizes required, engraved with engraver's standard letter style of sizes and wording indicated, white with black core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting necessary because of substrate.

B. Thickness: 1/8-inch.

C. Fasteners: Self-tapping stainless steel screws except contact type permanent adhesive where screws cannot or should not penetrate substrate.

D. 1 inch high letters.

PART 3 – EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

A. Where identification is to be applied to surfaces requiring painting or other finish, install identification after completion of finishing and painting.

3.02 DOOR SIGNS

A. Install engraved plastic laminate sign at each pedestrian door as indicated on Drawings.

B. Install in accordance with manufacturer's instructions.

C. Install plumb and level, securely anchored to door.

D. Mounting height and location: As required by accessibility regulations. Coordinate with Owner.

3.03 ADJUSTING AND CLEANING

A. Cleaning: Clean face of identification devices and doors.

END OF SECTION

SECTION 10 44 16
FIRE EXTINGUISHERS

PART 1 - GENERAL

1.01 SUMMARY

A. Provide portable fire extinguishers and mounting brackets for surface mounted fire extinguishers as specified herein, and as needed for a complete and proper installation.

1.02 SUBMITTALS

A. Product data:
   1. Manufacturer's information and specifications and other data needed to prove compliance with the specified requirements.
   2. Mounting instructions.

B. Shop Drawings: Fire extinguishers and mounting brackets. Include plans, elevations, section, details and attachments to other work.

C. Maintenance Data: Contractor shall provide manufacturer's maintenance data and coordinate with the Owner's existing fire extinguisher service to ensure fire extinguishers submitted are capable of being integrated into the Owner's current maintenance system.

D. Warranty: Sample of special warranty.

E. American Iron and Steel Compliance Certification:

   1. This project is being funded by the Clean Water State Revolving Fund that requires that all of the iron and steel products used in the project to be produced in the United States ("American Iron and Steel Requirement"). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R. 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.
   2. The Manufacturer shall provide with the shop drawing submittal one signed and dated Certification Letter (a sample copies of which are provided in the Appendix). The Certification Letter shall demonstrate compliance with Section 436 of federal H.R. 3547.

F. Comply with pertinent provisions of Section 01 33 00.

1.03 QUALITY ASSURANCE

A. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10; "Portable Fire Extinguishers"

B. Listed and labeled for type, rating and classification by an independent testing agency acceptable to authorities having jurisdiction.

C. Obtain fire extinguishers through one source from a single manufacturer.

1.04 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace fire extinguishers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to the following:

    a. Failure of hydrostatic test according to NFPA 10.
    b. Faulty operation of valves or release levers.

2. Warranty Period: Six years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 FIRE EXTINGUISHERS

A. Provide multi-purpose dry chemical fire extinguishers with UL rating of 4A:80B:C; 10 pound capacity, enameled steel tank with flexible hose and pressure gage, completely rechargeable.

B. Provide manufacturer's standard wall-mounting bracket for each fire extinguisher.

C. Service, charge, and tag each fire extinguisher not more than five calendar days prior to the Date of Substantial Completion.

2.02 MOUNTING BRACKETS

A. Mounting Brackets: Manufacturer's standard steel, designed to secure fire extinguisher to wall or structure, of sizes required for types and capacities of fire extinguishers indicated, with plated or black-enamel finish.

B. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate as indicated by Engineer.

C. Identify bracket-mounted fire extinguishers with the words "FIRE EXTINGUISHER" in red letter decals applied to mounting surface.

    1. Orientation: Vertical.

PART 3 - EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 INSTALLATION

A. Install in strict accordance with the manufacturer's recommended installation procedures, anchoring all components firmly into position for long life under hard use.

B. Locate and install extinguishers and brackets in accordance with NFPA 10 and where directed by the Fire Department official.

C. Mounting Brackets Fasten to structure, square and plumb.

D. Examine fire extinguishers for proper charging and tagging.

1. Remove and replace damaged, defective, or undercharged fire extinguishers.

E. Install mounting brackets so that the top of fire extinguishers is 54 inches above finish floor

END OF SECTION

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DIVISION 22

PLUMBING

SECTION 22 00 05
PLUMBING SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

A. This section includes plumbing equipment, fixtures, insulation and piping systems, including:

1. Plant Water Piping System:

a. Plant cold water piping (W4).

2. Soil and Waste Piping Systems:

a. Above ground soil, waste and vent piping in buildings including traps and connections to fixtures and drains.
b. Underground soil waste and vent piping terminating at connection to sanitary sewers 10 feet outside inner face of foundation wall.

3. Sump Pump and associated discharge piping.

4. Storm Water Piping Systems:

a. Conductor piping from roof drains and deck drains to storm building drain.
b. Storm building drain piping from conductor piping and area drains to storm sewers 10 feet outside inner face of foundation wall.

1.02 DEFINITIONS, ABBREVIATIONS AND ACRONYMS

A. Acronyms:

1. ABS: Acrylonitrile Butadiene Styrene
2. CPVC: Chlorinated Polyvinyl Chloride
3. CWP: Cold Working Pressure
4. DR: Dimension Ratio
5. DWV: Drain Waste Vent
6. EPDM: Ethylene Propylene Diene Monomer
7. HDPE: High Density Polyethylene
8. IDR: Inside Dimension Ratio
9. IPS: Iron Pipe Size
10. NPT: National Pipe Thread
11. O.S.&Y.: Outside Stem and Yoke
12. PE: Polyethylene
13. PEX: Crosslinked Polyethylene
14. PLC: Programmable Logic Controller, refer to Division 13 for interface requirements
15. PTFE: Polyetrafluoroethylene (Teflon®)
16. PVC: Polyvinyl Chloride
17. TEFC: Totally Enclosed Fan Cooled
18. TFE: Tetrafluoroethylene

B. Unit Abbreviations:

1. °F: Degrees Fahrenheit
2. Btu/Hr: British Thermal Units per Hour

3. CFM: Cubic Feet per Minute
4. GPH: Gallons per Hour
5. GPM: Gallons per Minute
6. HP: Horsepower
7. kW: Kilowatts
8. PSI: Pounds per Square Inch
9. RPM: Revolutions per Minute

1.03 REFERENCES

A. Code References:

1. ADA: Americans with Disabilities Act

B. Standard References:

1. ANSI: American National Standards Institute
2. ASME: American Society of Mechanical Engineers
3. ASSE: American Society of Sanitary Engineering
4. ASTM: American Society for Testing and Materials
5. AWWA: American Water Works Association
6. CISPI: Cast Iron Soil Pipe Institute
7. CDA: Copper Development Association Incorporated
8. CSA: Canadian Standards Association
9. MSS: Manufacturers Standardization Society
10. PDI: Plumbing and Drainage Institute
11. UL: Underwriters Laboratories Incorporated

1.04 SUBMITTALS

A. General:

1. Submit Product Data in sufficient detail to confirm compliance with requirements of this Section. Submit Product Data and Shop Drawings in one complete submittal package. Partial submittals are unacceptable.

B. Product Data - Submit manufacturer's technical data for all fixtures, drain, valves and equipment. Include in submittal, specifications, capacity ratings, pump curves showing scheduled operating point clearly identified, dimensions, weights, materials, accessories furnished, and installation instructions.

C. Shop Drawings - Submit assembly-type shop drawings showing unit dimensions, construction details, rough-in elevations, methods of assembly of components, and field connection details.

D. Wiring Diagrams - Submit manufacturer's electrical requirements for power supply wiring to equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

E. Maintenance Data - Submit maintenance data and parts list for piece of scheduled equipment, accessory, and control. Include this data and product data in maintenance manual in accordance with requirements of Division 1.

F. Submit in accordance with Section 01 33 00.

G. Operation and Maintenance (O&M) Data:

1. Operating instructions and maintenance data for materials and products for inclusion in O&M Manual.
2. Manufacturer's written instructions for periodic tests of equipment in service.
3. Submit in accordance with Section 01 78 23.

1.05 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide plumbing equipment, fixtures, insulation and piping from firms regularly engaged in manufacture of same types and sizes of equipment required, whose products have been in satisfactory use in similar service for not less then 3 years.

B. Plumbing Code Compliance: Comply with all applicable portions of building codes pertaining to plumbing materials, construction and installation of products.

1. Illinois Department of Public Health:

a. Part 890: Illinois Plumbing Code.

2. All local plumbing codes.

C. PDI Compliance: Comply with applicable PDI standards pertaining to products and installation of soil waste piping systems.

D. Manufacturer Qualifications: Firms experienced in manufacturing equipment of types and capacities indicated that have record of successful in-service performance.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment and system components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is made safe from such hazards.

B. Store equipment in clean, dry location.

PART 2 – PRODUCTS

2.01 GENERAL

A. Where more than one type is indicated, selection is Contractor's option or compliance with governing regulations

B. Size system drain piping as shown or, if not shown, as required to properly drain piping systems, including valves and equipment.

C. Manufacturer's equipment used as basis of design for project is name indicated in Specifications for particular type of equipment or application contained in these contract documents. If no manufacturer listed, basis of design is industry standard indicated.

2.02 DOMESTIC WATER PIPING SYSTEMS

A. Size 3 inch or smaller (W4):

1. Unless specifically indicated on the drawings or elsewhere to be stainless steel, material choice is Contractors option between PVC and Stainless Steel.

a. Stainless Steel Pipe:

1) ASME B36.19M, Schedule 40, seamless stainless steel, type 304L pipe.
2) Fittings: MSS SP-114, Class 150 threaded fittings.
3) Fittings: MSS SP-114, Class 150 socket-weld fittings.

b. Polyvinyl Chloride (PVC) Pipe:

1) Pipe Weight: Schedule 80, ASTM D1785.
2) Fittings: ASTM D2467, socket weld joints.
3) Joints: Solvent cement joints in accordance with ASTM D2855.

B. Size 4 inch or larger, buried or interior:

1. Cement-Lined Ductile Iron:

a. Furnish and install in accordance with Section 40 05 19.

2.03 SOIL, VENT AND STORM SYSTEM PIPING

A. Size 10 inch or smaller:

1. Polyvinyl Chloride (PVC) Pipe:

a. Pipe Weight: Type DWV, ASTM D2665.
b. Fittings: PVC Plastic, Type DWV, socket type.
c. Joints: Solvent cement joints in accordance with ASTM D2855.

2.04 SUMP PUMP PIPING

A. Size 3 inch or smaller:

1. Polyvinyl Chloride (PVC) Pipe:

a. Pipe Weight: Schedule 80, ASTM D1785.
b. Fittings: PVC Plastic, Schedule 80, socket type, ASTM 2466.
c. Joints: Solvent cement joints in accordance with ASTM D2855.

2.05 FLEXIBLE METAL HOSE

A. Manufacturer:

1. Unaflex.
2. Or Equal.

B. Internal flexible core of corrugated-type 321 stainless steel tubing.

C. 304 stainless steel external wire braid reinforcement.

D. For pipe sizes 2-1/2 inch and larger provide stainless steel flanged connection.

E. For pipe sizes 2 inch and smaller, provide stainless steel male NPT nipples.

2.06 VALVES

A. General:

1. Valves installed in insulated piping systems shall be furnished with extended stem as required to allow operation of valve without damage to or interference with insulation system.
2. Provide valves meeting the requirements of Section 40 05 53 and as indicated below:

a. Ball Valves 3 inch and smaller for stainless steel water service: Type V336.
b. Ball Valves 3 inch and smaller for PVC water service: Type V355.
c. Gate Valves: Type V416.
d. Sump Pump Check Valves: Type V274.

B. Wall Hydrants: (WH)

1. Manufacturers:

a. Mifab, MHY-1 series.
b. Woodford, Model 65.
c. Or equal.

2. Approved under ASSE Standard 1019-B.
3. 3/4 inch male hose thread connection.
4. Vacuum Breaker.
5. Freeze-proof.
6. Wall clamp.
7. Brass body with chrome plated face plate.
8. Non-potable sign and removable key handle.

C. Deck Hydrants: (DH)

1. Manufacturers:

a. Kupferle Foundry Company, Eclipse.
b. Or equal.

2. Self-draining, non-freezing, compression type hydrant.
3. 2-1/2 inch FIP inlet and 2 inch NPS outlet connections.
4. Hydrant shall have 3 inch ductile iron pipe riser with cast iron stock top and non-turning operating rod.
5. Interior parts shall be of brass construction and removable without excavating the hydrant.
6. Provide with 20 inch long below deck extension as required to clear deck slab with inlet valve body.
7. Furnish with deck mounting flange.
8. Tamper-proof removable handwheel option, provide each hydrant with handwheel.

2.07 FIXTURES

A. Service Sink: (SS):

1. Manufacturers:

a. Elkay, model ESSW2118C.
b. Or equal.

2. Wall mounted stainless steel service sink
3. Bowl dimensions 21”x17.5”x12”.
4. 14 gauge type 304 stainless steel.
5. Blank back.
6. Accessories:

    a. Cast iron P-trap, Elkay LK173

2.08 EQUIPMENT

A. Submersible Sewage Pumps:

1. Manufacturers:

    a. Weil.
    b. Or Equal.

2. Floor mounted submersible sewage pump capable of passing 2 inch solids with 2 inch NPT connections.
3. Performance:

    a. SP-101, -102:

        1) Weil model 2426.
        2) 40 gpm at 24 feet of water column head.
        3) 1 hp, 460 Volt/3-phase motor.
        4) Control Panel: SPCP-100.

4. Floor mount sewage pump.
5. Air filled, hermetically sealed motor.
6. Cast iron construction with stainless steel shaft.
7. Open bronze impeller, statically and dynamically balanced.
8. Ball type upper and lower bearings, permanently lubricated single row, double sealed, oversized to handle radial and axial loads.
9. Ceramic faced seal with heat resistant stainless steel and Buna-N components.
10. Stainless steel lifting chain of length required to reach top of existing sumps.
11. Provide with rectangular galvanized steel sump cover sized to cover 4’-0”x4’-0” sump. Cover shall be provided with gasketed access port for each pump, gasketed inspection port, power and control openings, and booted penetrations for two sump discharge pipes and one vent pipe.
12. Provide power cables of adequate length as required to connect pump to control panel.
13. Provide UL listed, NEMA 4X control panel (SPCP-100) of glass reinforced plastic construction for each set of pumps with following components:

    a. Main disconnect.
    b. Hand-Off-Auto switch for each pump.
    c. Selector switch for manual alternation.
    d. Combination motor starter with overloads.
    e. 115 volt control transformer with fused primary and secondary.
    f. Numbered and wired terminal board for controls.
    g. Lights to indicate pump run, high water alarm, control power, and motor overload.
    h. Door mounted hour meter for each pump.
    i. Diaphragm micro level switches for pumps off, lead pump on, lag pump on, and high water alarm. Mercury switches not acceptable.
    j. Alternator to alternate lead-lag pump operation.
    k. Provide extra contact closures to send alarm signal to Plant PLC on high water alarm.

B. Submersible Sump Pumps:

1. Manufacturers:

a. Weil.
b. Or Equal.

2. Floor mounted submersible wastewater pump capable of passing 1/2 inch solids with 2 inch NPT connections.
3. Performance:

a. SP-121, -122:

1) Weil model 1413 with 675 impeller.
2) 30 gpm at 40 feet of water column head.
3) 1-1/2 hp, 460 Volt/3-phase motor.
4) Control Panel: SPCP-120.

4. Floor mount wastewater pump.
5. Air filled, hermetically sealed motor.
6. Cast iron construction with stainless steel shaft.
7. Open bronze impeller, statically and dynamically balanced.
8. Ball type upper and lower bearings, permanently lubricated single row, double sealed, oversized to handle radial and axial loads.
9. Carbon against ceramic seal with heat resistant stainless steel and Buna-N components.
10. Stainless steel lifting chain of length required to reach top of existing sumps.
11. Provide power cables of adequate length as required to connect pump to control panel.
12. Provide UL listed, NEMA 4X control panel (SPCP-120) of glass reinforced plastic construction for each set of pumps with following components:

a. Main disconnect.
b. Hand-Off-Auto switch for each pump.
c. Selector switch for manual alternation.
d. Combination motor starter with overloads.
e. 115 volt control transformer with fused primary and secondary.
f. Numbered and wired terminal board for controls.
g. Lights to indicate pump run, high water alarm, control power, and motor overload.
h. Door mounted hour meter for each pump.
i. Diaphragm micro level switches for pumps off, lead pump on, lag pump on, and high water alarm. Mercury switches not acceptable.
j. Alternator to alternate lead-lag pump operation.
k. Provide extra contact closures to send alarm signal to Plant PLC on high water alarm.

2.09 DRAINAGE AND VENT PRODUCTS

A. Heavy Duty Floor Drains: (FD-1)

1. Manufacturers:

a. Zurn model Z-520.
b. J.R. Smith.
c. Or equal.

2. Provide sizes as indicated on plans.
3. Coated cast iron body with seepage pan and adjustable frame.

4. 9 inch diameter, heavy-duty cast iron deep flange slotted grate.

B. Floor Cleanouts: (CO)

1. Manufacturers:

a. Zurn model Z-1400
b. J.R. Smith.
c. Or equal.

2. Adjustable coated cast iron cleanout.
3. Round adjustable scoriated secured coated cast iron top.
4. Gas and watertight ABS tapered thread plug.

C. Roof Drains: (RD-1)

1. Manufacturers:

a. Zurn, Z100.
b. J.R. Smith, Figure 1010.
c. Or equal.

2. Provide sizes as indicated on plans.
3. Acid resisting epoxy coated.
4. Cast iron body with combined flashing clamp and gravel stop.
5. Aluminum dome.
6. Sump receiver.
7. Under deck clamp.
8. Insulation extension

2.10 ACCESSORIES

A. Water Hammer Arrestors:

1. Manufacturers:

a. Precision Plumbing Products.
b. Or Equal.

2. Provide where required by state codes, where indicated on drawings and Installation portion of this Section and as required for complete installation.
3. For CPVC or PVC piping systems:

a. CPVC, Schedule 80 construction, conforming to ASTM standard 1784 for materials and F411 for pipe.
b. Suitable for normal operating pressures of 35-100 psig and spike pressures to 250-psig.

4. For stainless steel piping systems:

a. 316 stainless steel construction.
b. Flanged or threaded end connections as dictated by unit size.
c. Suitable for normal operating pressures of 35-500 psig and spike pressures up to 2,000 psig.

5. Where no size indicated, provide unit one line size smaller than piping system size served.

2.11 INSULATION

A. Insulate in accordance with Section 40 42 13.

2.12 PIPING SPECIALTIES

A. Provide piping specialties in accordance with Section 40. Provide piping specialties from manufacturers regularly engaged in manufacture of piping specialties of type and sizes required for not less then 3 years.

B. Pipe Escutcheons: Provide pipe escutcheons with inside diameter closely fitting pipe outside diameter and outside diameter to completely cover pipe penetration and pipe sleeve extensions. Furnish pipe escutcheons with nickel or chrome finish.

C. Pipe Sleeves and Wall Collars: Provide pipe sleeves and wall collars of one of the following:

1. Sheet Metal: Round tube with snap lock joint, welded spiral seams or welded longitudinal joint. Fabricate from galvanized steel of the following gauges, 20 gauge for smaller then 4 inch, 16 gauge up to 6 inch, 14 gauge for all pipe sizes greater then 6 inch
2. Plastic Pipe: Provide sleeves fabricated of schedule 80 PVC pipe.
3. Iron Pipe: Provide ductile iron or cast iron pipe with integrally cast intermediate collar in exterior, water supporting and water retaining walls and slabs.
4. Steel Pipe: Provide seals fabricated of schedule 40 carbon steel pipe with welded center flange. Sleeve shall be hot-dipped galvanized when used for water stoppage.
5. Mechanical Sleeve Seals: Provide modular type sleeve seals consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates designed to cause rubber sealing elements to expand when tightened. Seal shall withstand 40 feet hydrostatic head of water.
6. Sleeve Seals: Provide sleeve seals for sleeves located in exterior walls or slab on grade floors with either elastomeric joint sealant or mechanical sleeve seals as described above.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which piping and equipment is to be installed. Do not proceed with installation until unsatisfactory conditions are corrected.

3.02 GENERAL

A. All work to conform to state and local plumbing and backflow prevention codes.

B. Install fixtures and equipment in accordance with manufacturer's installation instructions.

C. Trench, backfill and compact in accordance with Section 31 23 33.

D. Install pipe hangers, supports and anchors in accordance with local plumbing code and Section 40 05 07.

E. Install pipe insulation in accordance with Section 40 42 13.

F. Provide pipe identification in accordance with Section 40 05 97.

G. Install wall pipes, sleeves and seals in accordance with Section 40 05 09.

H. Install valves in accordance with Section 40 05 53.

3.03 PIPING INSTALLATION

A. General:

1. Install pipe, tube and fittings in accordance with recognized industry practices, local plumbing code and ANSI B31.9 - Building Service Piping.
2. Piping installations shall achieve permanently leakproof piping systems capable of performing each indicated service without piping failure.
3. Install each pipe run with minimum joints and couplings.
4. Provide unions at each valve and equipment connection.
5. Reduce sizes, where indicated, by use of reducing fittings.
6. Align piping accurately at connections, within 1/16 inch misalignment tolerance.
7. Where equipment connections differ from pipe sizes indicated on Drawings, route piping full size as indicated on drawings to unit including isolation valve and provide reducer as required at point of connection.
8. Non-metallic piping systems buried outside of the foundation of a structure shall be installed with tracer wire in accordance with Section 33 05 05.

B. Pipe Locations:

1. Locate piping runs, except otherwise indicated, vertically and horizontally (pitched to drain), and avoid diagonal runs wherever possible.
2. Orient horizontal runs parallel with walls, building column lines and other piping.
3. Locate runs, as shown or described by diagrams, plans, details and notations or, if not otherwise indicated, run piping in shortest route which does not obstruct usable space or block access for servicing building and equipment.
4. Hold piping close to walls, overhead construction, columns and other structural and permanent enclosure elements of building; limit clearance to 1/2 inch where furring is shown for enclosure for concealment of piping, but allow for insulation thickness, if any.
5. Where possible, locate insulated piping for 1.0 inch clearance outside insulation.
6. Wherever possible in finished and occupied spaces, conceal piping from view by locating in column enclosures, hollow wall construction or above suspended ceilings; do not encase horizontal runs in solid partitions, except as indicated.
7. Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures unless unavoidable or indicated to do so.
8. Install drip pan under piping that must be run through electrical spaces.

C. Piping System Joints:

1. Thread pipe in accordance with ANSI B2.1; cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint compound, or pipe joint tape (Teflon) where recommended by pipe/fitting manufacturer, on male threads at each joint and tighten joint to leave not more than 3 threads exposed.
2. Solder copper tube-and-fitting joints where indicated, in accordance with recognized industry practice. Cut tube ends squarely, ream to full inside diameter, and clean outside of tube ends and inside of tube fittings. Apply solder flux to joint areas of both tubes and fittings. Insert tube full depth into fitting, and solder in manner which will draw solder full depth and circumference of joint. Wipe excess solder from joint before it hardens.
3. Weld pipe joints in accordance with ANSI B31.
4. Hubless Cast-Iron Joints - Comply with CISPI 310.
5. Plastic Pipe/Tube Joints - Comply with manufacturer's instructions and recommendations, and with applicable industry standards, ANSI/ASTM D 2235, and ANSI/ASTM F 402.

D. Expansion Compensation:

1. Install piping including mains, branches and runouts with sufficient offsets to allow for free expansion and contraction, sufficient to prevent leaks and overstressing of piping system.

E. Water Hammer Arrestors:

1. Install in upright position in locations and of sizes in accordance with PDI-WH-201 and elsewhere as indicated and as noted below:

a. Provide line sized unit upsteam of each solenoid valve.

F. Installation of Soil, Storm and Vent Piping and Products:

1. Install soil and vent products in accordance with manufacturer's written installation instructions and local plumbing code.
2. General: Install underground building drains as indicated and in accordance with local plumbing code. Lay underground building drains beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install required gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements. Clean interior of piping of dirt and other superfluous material as Work progresses. Maintain swab or drag in line and pull past each joint as completed. Place plugs in ends of uncompleted piping at end of day or whenever Work stops.
3. Install horizontal piping on constant grade, avoiding pockets. Minimum grade of 1/8 inch per foot for mains and 1/4 inch per foot for branches.
4. Install cleanouts where indicated on drawings. In addition to where shown, provide cleanouts at ever 90 degree bend in soil and storm piping at maximum of 50 foot intervals for 3 inch and smaller soil piping and 100 foot intervals for 4 inch and larger soil piping.
5. Test soil and vent piping in accordance with requirement of local plumbing code.
6. Catch basin outlet pipe shall be installed with an elbow down within the basin, extending a minimum of 6 inch below the invert of the outlet pipe.
7. Floor Drains:

a. General: Install floor drains in accordance with manufacturer's written instructions and in locations indicated.
b. Coordinate with soil and waste piping as necessary to interface floor drains with drainage piping systems.
c. Install floor drains at low points of surface areas to be drained or as indicated. Set tops of drains flush with finished floor.
d. Install drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
e. Position drains so accessible and easy to maintain.

8. Roof Drains:

a. General: Install drains in accordance with manufacturer's written instructions and locations indicated.
b. Coordinate with roofing necessary to interface roof drains with roofing work.
c. Under deck clamp for roof drains shall cover entire roof penetration and fit tightly to drain pipe or body such that the roof penetration is not visible from below.
d. Coordinate with storm water piping necessary to interface drains with drainage piping systems.
e. Install drains at low points of surface areas to be drained or as indicated.
f. Install drain flashing collar or flange so no leakage occurs between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
g. Position drains so they are accessible and easy to maintain.

3.04 WATER SERVICE

A. Water main entrance into building shall be ductile iron.

B. Schedule any interruption of the existing water service with the Owner.

3.05 FIXTURES

A. General:

1. Install in accordance with manufacturer's written installation instructions and with local plumbing codes.
2. Install plumbing fixtures of types indicated where shown and at indicated heights, in accordance with fixture manufacturer's written instructions, roughing-in drawings, and recognized industry practices. Ensure plumbing fixtures comply with requirements and serve intended purposes. Comply with applicable requirements of Plumbing Code pertaining to installation of plumbing fixtures.
3. Verify locations and coordinate with architectural designs and other devices and equipment, as approved by Engineer before roughing-in connections.
4. Examine floors, substrates, and conditions under which fixture work to be accomplished.
5. Correct incorrect locations of piping and other unsatisfactory conditions for installation of plumbing fixtures.
6. Do not proceed with Work until unsatisfactory conditions corrected
7. Operation of fixtures shall be tested for proper operation and adjusted for field connections and service use, as required.
8. Fasten plumbing fixtures securely to indicated supports or building structure level and plumb. Secure plumbing supplies behind or within wall construction to be rigid and not subject to pull or push movement.
9. Protect installed fixtures from damage during remainder of construction period.
10. Do not use new fixtures during construction unless approved in writing by Owner.
11. Upon completion of installation and after units are water pressurized, test fixtures to demonstrate capability and compliance with requirements. When possible, correct malfunctioning units at site, then retest to demonstrate compliance, or remove and replace with new units and proceed with retesting.
12. Inspect each installed unit for damage to finish. If feasible, restore and match finish to original at site, or remove fixture and replace with new unit. Feasibility and match to be judged by Engineer. Remove cracked or dented units and replace with new units
13. Clean plumbing fixtures, trim, and strainers of dirt and debris upon completion of installation.

3.06 EQUIPMENT

A. General:

1. Install in accordance with manufacturer's written installation instructions and with local plumbing codes.
2. Verify locations and coordinate with architectural designs and other devices and equipment, as approved by Engineer before roughing-in connections.
3. Operation of fixtures shall be tested for proper operation and adjusted for field connections and service use, as required.

B. Sump Pumps:

1. Install in accordance with manufacturer's written installation instructions and local plumbing code.

2. Provide union, check valve and isolation valve on sump pump discharge piping.
3. Provide offsets and transitions as required to connect to existing discharge piping.
4. Set float switches at Manufacturer recommended elevation for pump off. Set Pump On float at 18 inch above bottom of sump, Lag Pump On at 24 inch above bottom of sump, and High Water Alarm shall be set to 6 inch below top of sump. Wire switches to control panel.
5. After piping complete, startup shall be by Plumber.

3.07 VALVES

A. Install valves in accordance with manufacturer's written installation instructions and local plumbing code.

B. Sectional Valves - Install on each branch and riser, close to main, where branch or riser serves 2 or more plumbing fixtures or equipment connections, and elsewhere as indicated.

C. Shutoff Valves - Install on inlet of each piece of plumbing equipment, and on inlet of each plumbing fixture, and elsewhere as indicated.

D. Drain Valves - Install on each plumbing equipment item located to completely drain equipment for service or repair. Install at base of each riser, at base of each riser or drop in piping system, and elsewhere where indicated or required to completely drain domestic water piping system.

E. Backflow Preventers:

1. Maintain minimum clearances for servicing and testing.
2. Provide indirect waste piping with air gap installation from relief opening to above hub drain or floor drain.
3. Provide initial registration, testing and report filing required by local plumbing code. List the name and address of the building that the backflow preventer installations occur in.

F. Pressure Reducing and Relief Valves – Install per Manufacturer’s written installation instructions. Install pressure gauges upstream and downstream of reducing valves. Adjust pressure settings as indicated.

3.08 PIPE INSULATION

A. Insulate all W4 piping systems in their entirety.

B. Install pipe insulation in accordance with manufacturer's written installation instructions.

C. Insulation shall not be installed until testing and acceptance of piping systems has been completed.

D. Install insulation for each continuous run of piping with full-length units, do not use scraps or cut pieces abutting each other.

E. Install insulation on domestic hot, cold and horizontal storm water piping.

F. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation, install factory molded or precut on job fabricated units.

3.09 TESTING PIPING SYSTEMS

A. Test piping system in accordance with Section 40 05 10 and local plumbing code.

END OF SECTION

DIVISION 23

HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Drawings and General Requirements of contract including General and Supplementary Conditions and Division 1 specification sections apply to work of this Section.

B. Extent of testing, adjusting, and balancing work is indicated by requirements of this section, and also by drawings and schedules, and is defined to include, but is not necessarily limited to:

1. Air distribution systems and associated equipment.

C. The work consists of setting speed and volume (flow) adjusting facilities provided for systems, recording data, conducting tests, preparing and submitting reports, and recommending modifications to work as required by contract documents.

D. Component types of testing, adjusting, and balancing specified in this section includes the following as applied to mechanical equipment:

1. Makeup air units.
2. Rooftop units.
3. Fans.
4. uctwork systems.

1.02 QUALITY ASSURANCE

A. A firm certified by National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) in those testing and balancing disciplines similar to those required for this project.

B. Comply with American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) recommendations pertaining to measurements, instruments and testing, adjusting and balancing, except as otherwise indicated and NEBB "Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems".

1.03 SUBMITTALS

A. Submit certified test reports signed by Test and Balance (TAB) Supervisor who performed TAB work.

B. Reports shall be on NEBB forms unless other forms have been approved by the Engineer prior to the start of testing.

C. Include identification and types of instruments used and their most recent calibration date with submission of final test report.

D. Include copies of certified test reports in maintenance manuals.

1.04 JOB CONDITIONS

A. Do not proceed with testing, adjusting, and balancing work until work has been completed and is operable. Ensure that there is no work still to be completed.

B. Do not proceed until work scheduled for testing, adjusting, and balancing is clean and free from debris, dirt and discarded building materials.

PART 2 - PRODUCTS

2.01 PATCHING MATERIALS

A. Except as otherwise indicated, use same products as used by original Installer for patching holes in insulation, ductwork and housings which have been cut or drilled for test purposes, including access for test instruments, attaching jigs, and similar purposes.

B. At Tester's option, plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned and is operable. Do not proceed with TAB work until unsatisfactory conditions have been corrected in manner acceptable to Tester.

3.02 TEST AND ADJUSTMENT

A. Test, adjust and balance environmental systems and components, as indicated, in accordance with procedures outlined in applicable standards.

B. Prepare report of test results, including instrumentation calibration reports, in format recommended by applicable standards.

C. Air side system balancing shall include but not be limited to the following procedures:

1. Test and adjust fan RPM to design requirements. For fans operating with pressure controlled VFDs, fan speed shall first be set to lowest output that allows design flow to most remote terminal served. Measured minimum required supply air pressure shall be identified to the Temperature Controls Contractor for establishing setpoint in the FMS.
2. Test and record motor full load amperage.
3. Check all fans for correct rotation.
4. Test and record system static pressures, suction, discharge and external at all air handling equipment.
5. Test and adjust system for design outside air and recirculated air quantities.
6. Adjust and record all main supply and return air ducts and zones to proper design CFM.
7. Test and adjust each diffuser, grille and register to within 10% of design requirements. Record data and location. Use manufacturer's rating and calculations.
8. Adjust all grilles to minimize drafts in all areas.
9. Test and record all air temperatures - supply, return, mixed, and outside air.

D. The contractor shall include the cost of new sheaves and belts if it becomes necessary to change the drives during balancing of system.

E. Patch holes in ductwork and housings, which have been cut or drilled for test purposes, in manner recommended by original Installer.

F. Mark equipment settings, including damper control positions, fan speed control levers, and similar controls and devices, to show final settings at completion of TAB work. Provide markings with paint or other suitable permanent identification materials.

G. Balancing contractor shall coordinate damper position settings with temperature control contractor to verify airflows and positions. Include time for this verification. See HVAC controls specification for time included by temperature controls contractor to work with balancing contractor.

H. Balancing contractor to work with temperature control contractor and HVAC contractor to verify correct operation of entire HVAC system, before submitting report.

END OF SECTION

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SECTION 23 07 00
HVAC INSULATION

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Drawings and General Requirements of contract including General and Supplementary Conditions and Division 1 specification sections apply to work of this Section.

B. Extent of mechanical insulation specified in this section includes Piping and Ductwork Systems (where indicated).

1.02 QUALITY ASSURANCE

A. Installation shall meet the requirements Illinois Mechanical and Energy Codes.

B. Manufacturer - Subject to compliance with requirements, provide products of one of the following:

1. Armstrong World Industries, Inc.
2. Certainteed Corp.
3. Knauf Fiberglass
4. Manville Corp.
5. Owens-Corning Fiberglass Corp.
6. Pittsburg Corning Corp.
7. Rubatex Corp.

C. Installer - A firm with at least 3 years successful installation experience on projects with mechanical insulation similar to that required for this project.

D. Flame/Smoke Ratings - Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread rating of 25 or less, and smoke-developed rating of 50 or less, as tested by ANSI/ASTM E 84 (NFPA 255) method.

1.03 SUBMITTALS

A. Product Data - Submit manufacturer's specifications and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, thickness, and furnished accessories for each mechanical system requiring insulation in accordance with Section 01 33 00.

B. Maintenance Data - Submit maintenance data and replacement material lists for each type of mechanical insulation in accordance with Section 01 78 23.

1.04 DELIVERY, STORAGE AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or level, affixed showing fire hazard ratings of products.

B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged insulation; remove from project site.

PART 2 – PRODUCTS

2.01 DUCTWORK INSULATION MATERIALS

A. External Duct Insulation:

1. Rigid Fiberglass Ductwork Insulation: ASTM C612, rigid fibrous glass board. Knauf Insulation Board, or equal.

a. Nonload Bearing: ASTM C612, Type IA; HH-I-558C, Form A, Class 1, average density 1.5 pcf, maximum k = 0.24 Btu in./hr sq ft °F at 75°F. Suitable for operating temperatures to 400°F.
b. Load Bearing: ASTM C612, Type IB; HH-I-558C, Form A, Class 2, average density 6.0 pcf, maximum k = 0.22 Btu in./hr sq ft °F at 75°F. Suitable for operating temperatures to 400°F.
c. Jacketing: Aluminum Foil Faced Vapor Barrier Material: All service type aluminum foil and fiberglass yarn reinforced kraft paper. FSK type conforming to ASTM C1136 Type II.

d. Maximum water vapor permeability, ASTM E96, 0.02 perms.

2. Flexible unicellular closed foam. Armacell AP Armaflex or Equal

a. Self-adhering duct wrap.
b. Plenum rated, meets ASTM E 84 25/50 fire and smoke ratings.
c. Water absorption less than 0.2%.
d. Suitable operating temperatures of -30°F to 180°F.
e. Thermal conductivity at 75°F less than 0.245 Btu-in/h-ft^2-°F.
f. Black color.
g. Exterior ductwork insulation systems shall be provided with a multi-ply laminated membrane, ArmaTuff, or Equal. System shall be a 13-ply laminate (6 layers of aluminum foil, 4 layers of polyester film around a scrim reinforcing core) membrane with a 10-yr warranty against UV related breakdown.

PART 3 - EXECUTION

3.01 SYSTEM INSULATION

A. HVAC Ductwork Insulation:

1. Insulate all exhaust air ductwork within 3'-0" of building exit or from damper to building exit, whichever is greater. Insulate with 2 inch thickness of load bearing rigid fiberglass ductwork insulation.
2. Insulate all outside air ductwork from building entrance to air handling unit connection with 2 inch thickness of load bearing rigid fiberglass ductwork insulation.
3. Insulate all Rooftop unit supply and return air ductwork, not in Mechanical Room and located elsewhere not being heat or cooled by equipment with 1 inch thickness of load bearing rigid fiberglass ductwork insulation.

3.02 INSTALLATION OF INSULATION

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

B. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

C. Maintain integrity of vapor-barrier jackets on insulation, and protect to prevent puncture or other damage.

D. Cover fittings and similar items in each system with equivalent thickness and composition of insulation as applied to adjoining run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.

E. Extend insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise indicated.

F. Install protective metal shields and insulated inserts wherever needed to prevent compression of insulation.

3.03 PROTECTION AND REPLACEMENT

A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION

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SECTION 23 09 23
DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC

PART 1 – GENERAL

1.01 SUMMARY

A. Furnish all labor, materials, equipment, and service necessary for a complete and operating Building Automation System (BAS), utilizing Direct Digital Controls (DDC) and electronic controls as described herein. The systems shall be capable of total integration of the facility infrastructure systems with user access to all system data either locally over a secure Intranet within the building or by secure remote access by a standard Web Browser over the Internet. This shall include HVAC control, energy management, alarm monitoring, and all trending, reporting and maintenance management functions related to normal building operations all as indicated in this specification.

B. The Building Automation System shall include:

1. Programmable Controllers.
2. Input/Output Modules as required.
3. Individual BACNet Routers or Building Controller with routing capabilities.
4. Other components required for a complete and working BAS.

C. Control wiring and power wiring between field installed controls, indicating devices and unit control panels for temperature control systems, is work of this Section to be installed in accordance with Division 26. Line or low voltage power wiring required for control devices including, but not limited to motor operated dampers, sensors, control valves, and thermostats that are not powered by equipment served shall receive power from the nearest temperature control panel (TCP) as work of this Section. Coordinate total ampere load in panel with Electrical Contractor to determine total number of circuits required at the TCP.

D. All equipment and wiring located in areas designated as Class I, Division 1, Group D Hazardous Classified Location, shall be suitable for this rating and installed in accordance with Division 26.

1.02 DEFINITIONS AND ABBREVIATIONS

A. Definitions:

1. BACnet Interoperability Building Blocks (BIBB)	A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBS are combined to build the BACnet functional requirements for a device in a specification.
2. BACnet/IP	An approved BACnet network type which uses an Ethernet carrier and IP addressing.
3. BACnet MS/TP	An approved BACnet network type which uses a Master-Slave Token Passing configuration. MS/TP networks are unique to BACnet and utilize EIA485 twisted pair topology running at 9600 to 76,800 bps
4. BACnet over ARCNET	An approved BACnet network type which uses an ARCNET (attached resource computer network) carrier. ARCNET is an industry standard that can utilize several speeds and wiring standards. The most common configuration used by BACnet controllers is an EIA485 twisted pair topology running at 156,000 bps

5.	BACnet/BACnet Standard	BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.
6.	Control Systems Server	A computer(s) that maintain(s) the systems configuration and programming database.
7.	Controller	Intelligent stand-alone control device. Controller is a generic reference to building controllers, custom application controllers, and application specific controllers.
8.	Direct Digital Control	Microprocessor-based control including Analog/Digital conversion and program logic.
9.	Gateway	Bi-directional protocol translator connecting control systems that use different communication protocols.
10.	Local Area Network	Computer or control system communications network limited to local building or campus.
11.	Master-Slave/Token Passing	Data link protocol as defined by the BACnet standard.
12.	Point-to-Point	Serial communication as defined in the BACnet standard.
13.	Primary Controlling LAN	High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs. Refer to System Architecture below.
14.	Protocol Implementation Conformance Statement (PICS)	A written document that identifies the particular options specified by BACnet that are implemented in a device.
15.	Router	A device that connects two or more networks at the network layer.
16.	Smart Actuator (SA)	An actuator which is controlled by a network connection rather than a binary or analog signal. (0-10v, 4-20mA, relay, etc.)
17.	Smart Sensor (SS)	A sensor which provides information to the BAS via network connection rather than a binary or analog signal. (0-10000 ohm, 4-20mA, dry contact, etc.)
18.	Web Services	Web services are a standard method of exchanging data between computer systems using the XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services can be used at any level within a Building Automation System (BAS), but most commonly they are used to transfer data between BAS using different protocols or between a BAS and a non-BAS system such as a tenant billing system or a utility management system
19.	Wiring	Raceway, fittings, wire, boxes and related items.

1.03 SYSTEM DESCRIPTION

A. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system Supervisory Server, and a web-based operator interface.

B. Contractor shall implement a Niagara Framework based open system that will allow products from various suppliers to be integrated into a unified system in order to provide flexibility for

expansion, maintenance, and service of the system. The Owner shall be the named license holder of all software associated with any and all incremental work on the Contract. Only Niagara Framework based products running on Version 4 or newer are acceptable.

C. The Owner shall receive ownership of all job specific configuration documentation, data files and application-level software developed for the Contract. This shall include all custom, job specific software code, databases and documentation for all configuration and programming that is generated for the Contract and/or configured for use with the NAC, FMCS Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required IDs and passwords for admin and programming level access to any component or software program shall be provided to the Owner.

D. It is the Owner's intent to purchase an open system capable of being serviced and expanded by any acceptable system integrator that has and maintains certification (TCP) to work on Niagara Framework systems. The Niagara Compatibility Statement (NICS) for all Niagara Software shall allow open access and be set as follows: accept.station.in="*" accept.station.out="*" accept.wb.out="*" accept.wb.in="*". In any case, the Owner shall maintain the right to direct Contractor to modify any software license, regardless of supplier, as desired by the Owner. The Contractor shall not install any "brand specific" software, applications or utilities on Niagara Framework based devices.

E. All hardware installed for the Contract shall not be limited in their ability to communicate with a specific brand of Niagara Framework device. They shall also be constructed in a modular fashion to permit the next generation and support components to be installed in replace of or in parallel with existing components.

F. System shall use the BACnet protocol for communication to the web server and for communication between control modules. I/O points, schedules, setpoints, trends and alarms specified in Control Sequences shall be BACnet objects.

1.04 SYSTEM PERFORMANCE

A. Performance Standards. System shall conform to the following minimum standards over network connections.

1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
4. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
5. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 45 sec.
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
8. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.
9. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed below:

Measured Variable	Reported Accuracy
Space Temperature	±1ºF
Ducted Air	±1ºF
Outside Air	±2ºF
Dew Point	±3ºF
Delta-T	±0.25ºF
Air Pressure (ducts)	±0.1 in. w.g.
Air Pressure (space)	±0.01 in. w.g.
Electrical	±1% of reading (not including Utility meters)

10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed below:

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±0.2 in. w.g. ±0.01 in. w.g.	0–6 in. w.g. -0.1 to 0.1 in. w.g.
Airflow	±10% of full scale	
Space Temperature	±2.0ºF	
Duct Temperature	±3ºF	
Humidity	±5% RH	

1.05 SUBMITTALS

A. General:

1. Submit Product Data in sufficient detail to confirm compliance with requirements of this Section. Submit Product Data and Shop Drawings in one complete submittal package. Partial submittals are unacceptable.

A. Installer Experience: Submit documentation that installer has a minimum of 5-years of experience in installations with the proposed Manufacturer's equipment and Niagara certification.

B. Product Data and Shop Drawings: Contractor shall provide shop drawings or other submittals on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have been approved for conformity with design intent. Provide drawings as AutoCAD 2012 (or newer) compatible files on magnetic or optical disk (file format: .DWG, .DXF, .VSD, or comparable) and three 11" x 17" prints of each drawing. When manufacturer's cutsheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Submittals shall include:

1. DDC System Hardware:

a. A complete bill of materials to be used indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.

b. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:

1) Direct digital controllers (controller panels)
2) Transducers and transmitters
3) Sensors (including accuracy data)
4) Actuators
5) Valves
6) Relays and switches
7) Control panels
8) Power supplies
9) Batteries
10) Operator interface equipment
11) Wiring

c. Wiring diagrams and layouts for each control panel. Show termination numbers.
d. Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware. Riser diagrams showing control network layout, communication protocol, and wire types.

2. Central System Hardware and Software:

a. A complete bill of material of equipment used indicating quantity, manufacturer, model number, and relevant technical.
b. Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:

1) Power supplies
2) Battery backups
3) Interface equipment between server and control panels
4) Operator interface software
5) Color graphic software
6) Third-party software

c. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show interface wiring to control system.
d. Network riser diagrams of wiring between central control unit and control panels.

3. Controlled Systems:

a. Riser diagrams showing control network layout, communication protocol, and wire types.
b. A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.
c. A schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.
d. An instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
e. A mounting, wiring, and routing plan-view drawing. The design shall take into account HVAC, electrical, and other systems' design and elevation requirements. The drawing

shall show the specific location of all concrete pads and bases and any special wall bracing for panels to accommodate this work.

f. A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.

g. A point list for each control system. List all I/O points and software points. Indicate alarmed and trended points.

4. Quantities of items submitted shall be reviewed but are the responsibility of the Contractor.
5. Description of process, report formats, and checklists to be used for Control System Demonstration and Acceptance.
6. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.

C. Project Record Documents. Upon completion of installation, submit three copies of record (as-built) documents of the documents shall be submitted for approval prior to final completion and shall include:

1. Project Record Drawings. As-built versions of submittal shop drawings provided as AutoCAD 2012 (or newer) compatible files on magnetic or optical media (file format: .DWG, .DXF, .VSD, or comparable) and as 11" x 17" prints.
2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Control System Demonstration and Acceptance.
3. Operation and Maintenance (O&M) Manual.
4. As-built versions of submittal product data.
5. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
6. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
7. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
8. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
9. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.
10. Graphic files, programs, and database on magnetic or optical media.
11. List of recommended spare parts with part numbers and suppliers.
12. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
13. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
14. Licenses, guarantees, and warranty documents for equipment and systems.
15. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

D. Training Materials: Provide course outline and materials for each class at least six weeks before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. Engineer will modify course outlines and materials if necessary to meet

Owner's needs. Engineer will review and approve course outlines and materials at least three weeks before first class

E. Submit in accordance with Section 01 33 00.

F. Operation and Maintenance (O&M) Data:

1. Maintenance Data - Submit maintenance data and spare parts lists for each type of control device. Include this data in maintenance manual. At a minimum include:

a. Maintenance instructions and schedule of recommended maintenance for pieces of equipment that require routine maintenance.
b. Sequence of Operation.
c. Logic diagrams.
d. Wiring Diagram.
e. Recommended spare parts list.

2. Operation and Maintenance Manuals:

a. Preparation and submittal of operation and maintenance data shall be in accordance with Section 01 78 23. Contractor is advised that Section 01 78 23 contains specific information related to the submission of O&M data in an electronic version. The Owner will be compiling both a paper and a computer-based O&M manual, and the vendor will need to provide a CD version of the O&M manual information.

1.06 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of electric, and digital control equipment of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. The Manufacturer of the DDC controllers shall provide documentation supporting compliance with ISO-9001 (Model for Quality Assurance in Design/Development, Production, Installation and Servicing). Product literature provided by the FMCS digital controller manufacturer shall contain the ISO-9001 Certification Mark from the applicable registrar.

C. Installer:

1. Provide documentation showing a minimum of 5-years of experience installing submitted Manufacturer's equipment for projects of similar size and scope.
2. Provide documentation showing Niagara 4 certification and a minimum of 2-years of experience with Niagara 4 Supervisory Server integration.

D. Electrical Standards: Provide electrical products which have been tested, listed and labeled by Underwriters' Laboratories (UL) and comply with NEMA standards.

E. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for electric-electronic temperature control systems.

F. NFPA Compliance: Comply with NFPA No. 90A where applicable to controls and control sequences.

G. Single-Source Responsibility: Obtain DDC components from single manufacturer with responsibility for entire system.

H. Regulatory Requirements:

1. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to the receipt of bids of the following codes:

    a. National Electric Code (NEC)
    b. International Building Code (IBC)
    c. International Mechanical Code (IMC)
    d. ANSI/ASHRAE Standard 135, BACnet - A Data Communication Protocol for Building Automation and Control Systems

1.07 DELIVERY, STORAGE, AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment, and control device. Maintain cartons through shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protected from weather.

1.08 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to insure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers, and structural and architectural features

1.09 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:

    1. Graphics
    2. Record drawings
    3. Database
    4. Application programming code
    5. Documentation

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Provide Direct Digital Control components from the following list of acceptable Manufacturers. Acceptable Manufacturers for field devices and auxiliary control devices shall be as indicated in component specific paragraphs.

    1. Distech Controls, Inc.
    2. Automated Logic.
    3. Honeywell, Inc.
    4. Trane.

2.02 INSTALLER

A. Acceptable Installers:

    1. Technical Solutions and Services Incorporated

2. Or equal.

B. Certification: Shall be certified by Tridium for Niagara 4 framework systems. Provide evidence of Niagara 4 certification as part of the submittal process.

C. Qualifications: The Contractor shall have a successful history in the design, installation and maintenance of Niagara 4 Framework based building automation systems to provide web browser monitoring and control of BACnet field level devices. Contractor must have previous experience in BAS installations and in DDC installation projects with point counts comparable to this Contract and systems of the same character as this Contract.

D. Installer shall have an established working relationship with Direct Digital Controls components Manufacturer and be an Authorized Integrator for components offered by Manufacturer with a minimum 5-years of documented experience with Manufacturer.

E. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.

F. Installer and BAS Contractor, when used in this Section refer to the same entity.

2.03 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135.

B. Install new wiring and network devices as required to provide a complete and workable control network. All wiring to be installed meeting the requirements of Division 26.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.
2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute specified control sequences. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

E. Building Control Panels and Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight saving and standard time as applicable.

F. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

2.04 OPERATOR INTERFACE

A. Supervisory Server Software:

1. None required. System will interface with Owner existing Niagara 4 server software at a later date. System shall be configure to allow ease of future interface.

B. Operator Interface, three modes:

1. Each Ventilation Control Panel (VCP) shall be provided with a BACnet compliant, IP based resistive touchscreen color display for access to all system settings and alarms. Screen size shall be 10 inch minimum.
2. Each VCP shall include a Network Controller (NC) which shall be capable of interfacing with Owner's portable computer through an Ethernet port on the controller. Furnish Owner nay product specific software required for interface with system and individual controllers.
3. Future connection to plant wide Niagara 4 Server.

C. Communication. Web server and controllers shall communicate using BACnet protocol. Web server and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135.

D. System Software.

1. System Graphics. The operator interface software shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.

   a. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
   b. Animation. Graphics shall be able to animate by displaying different image files for changed object status.
   c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
   d. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Adobe Flash).

2. Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in the same formats as are used for system graphics.
3. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.

E. System Applications. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each web browser interface. If furnished as a

stand-alone program, software shall be provided to allow installation on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.

1. Automatic System Database Configuration. Each web server shall store on its memory a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
2. Manual Controller Memory Download. Operators shall be able to download memory from the system database to each controller.
3. System Configuration. Software shall be provided, installable on an Owner furnished computer that provides a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection. Operators shall be able to configure the system.
4. On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
5. Security. Each operator shall be required to log on to the system with user name and password in order to view, edit, add, or delete data.

    a. Operator Access. The user name and password combination shall define accessible viewing, editing, adding, and deleting privileges for that operator. Users with system administrator rights shall be able to create new users and edit the privileges of all existing users. System Administrators shall also be able to vary and deny each operator's privileges based on the geographic location, such as the ability to edit operating parameters in Building A, to view but not edit parameters in Building B, and to not even see equipment in Building C.
    b. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. This auto logoff time shall be user adjustable.
    c. Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.

6. System Diagnostics. The system shall automatically monitor the operation of all building management panels and controllers. The failure of any device shall be annunciated to the operator.
7. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified. Unless specific external hardwired alarm specified, alarms shall be BACnet alarm objects and shall use BACnet alarm services.
8. Alarm Messages. Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying on acronyms.
9. Alarm Reactions. Operator shall be able to configure (by object) what, if any actions are to be taken during an alarm.
10. Alarm and Event log. Operators shall be able to view all system alarms and changes of state from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and delete alarms, and archive closed alarms to the workstation or web server hard disk.
11. Trend Logs. The operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to memory. Trends shall be BACnet trend objects.

12. Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object or property in the system. The status shall be available by menu, on graphics, or through custom programs.
13. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
14. Standard Reports. Furnish the following standard system reports:

    a. Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
    b. Alarm Summary. Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
    c. Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:

        1) Alarm History.
        2) Trend Data. Operator shall be able to select trends to be logged.
        3) Operator Activity. At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

15. Custom Reports. Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations, and that present results in tabular or graphical format. Reports shall be launched from the operator interface.

F. Application Editors. Shall support editing of all system applications. The applications shall be downloaded and executed at one or more of the controller panels.

1. Controller. Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.
2. Scheduling. An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and schedule type. Exception schedules and holidays shall be shown clearly on the calendar. The start and stop times for each object shall be adjustable from this interface.
3. Custom Application Programming. Provide the tools to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:

    a. Language. Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.
    b. Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.
    c. Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.
    d. Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.

e. Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
f. Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.
g. Variables. Operator shall be able to use variable values in program conditional statements and mathematical functions.

1) Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.
2) System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

G. Portable Operator's Terminal. Provide all necessary software to configure an IBM-compatible laptop computer for use as a Portable Operator's Terminal. Operator shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting.

2.05 CONTROLLER SOFTWARE

A. Furnish the following applications for building and energy management. All software applications shall reside and operate in the system controllers. Applications shall be editable through portable operator's terminal, or web browser interface. All software required to access, review, and modify controller programs shall be furnished to the Owner.

B. Scheduling. Provide the capability to execute control functions according to a user created or edited schedule. Each schedule shall provide the following schedule options as a minimum:

1. Weekly Schedule. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).
2. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule has executed, the system shall discard and replace the exception schedule with the standard schedule for that day of the week.
3. Holiday Schedules. Provide the capability for the operator to define up to 24 special or holiday schedules. These schedules will be repeated each year. The operator shall be able to define the length of each holiday period.

C. System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

D. Binary Alarms. Each binary object shall have the capability to be configured to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.

E. Analog Alarms. Each analog object shall have both high and low alarm limits. The operator shall be able to enable or disable these alarms.

F. Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display on graphics.

G. Maintenance Management. The system shall be capable of generating maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in Control Sequences.

H. Sequencing. Application software shall sequence equipment as specified in Control Sequences.

I. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs. The calculation interval, PID gains, and other tuning parameters shall be adjustable by a user with the correct security level.

J. Staggered Start. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

K. Energy Calculations:

1. The system shall accumulate and convert instantaneous power (kW) or flow rates (gpm) to energy usage data.
2. The system shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.

L. Anti-Short Cycling. All binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

M. On and Off Control with Differential. Provide an algorithm that allows a binary output to be cycled based on a controlled variable and a setpoint. The algorithm shall be direct-acting or reverse-acting.

N. Runtime Totalization. Provide software to totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as specified in Control Sequences.

2.06 CONTROLLERS

A. General. Provide an adequate number of Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified in System Performance paragraph. Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart Sensors. Controllers shall be readily available for purchase and integration by any installer, Owner, or Contractor without the need for a distributor agreement to purchase. Programming software shall be made available to Owner.

B. BACnet:

1. Network Controller (NC)

a. Network Controllers shall be Niagara 4 Framework style from the following list of acceptable Manufacturers:

1) Distech EC-BOS-8
2) Honeywell, WEB-8000;
3) Johnson Controls, FX80;
4) Tridium, JACE 8000;

5) Vykon, JACE 8000;
6) or equal.

b. These controllers are designed to manage communications between the programmable equipment controllers (PEC), application specific controllers (ASC) and advanced unitary controllers (AUC) which are connected to its communications trunks, manage communications between itself and other network controllers (NC) and with any operator workstations (OWS) that are part of the BAS, and perform control and operating strategies for the system based on information from any controller connected to the BAS.
c. The controllers shall be fully programmable to meet the unique requirements of the facility it shall control.
d. The controllers shall be capable of peer-to-peer communications with other NCs and with any OWS connected to the BAS, whether the OWS is directly connected, connected via cellular modem or connected via the Internet.
   1) The communication protocols utilized for peer-to-peer communications between NCs will be Niagara 4 Fox, BACnet TCP/IP and SNMP. Use of a proprietary communication protocol for peer-to-peer communications between NC's is not allowed.
e. The NC shall employ a device count capacity license model that supports expansion capabilities.
f. The NC shall be enabled to support and shall be licensed with the following Open protocol drivers (client and server) by default:

   1) BACnet
   2) Lon
   3) MODBUS
   4) SNMP

g. The NC shall be capable of executing application control programs to provide:

   1) Calendar functions.
   2) Scheduling.
   3) Trending.
   4) Alarm monitoring and routing.
   5) Time synchronization.
   6) Integration of LonWorks, BACnet, and MODBUS controller data.
   7) Network management functions for all NC, PEC and ASC based devices.

h. The NC shall provide the following hardware features as a minimum:

   1) Two 10/100 Mbps Ethernet ports.
   2) Two Isolated RS-485 ports with biasing switches.
   3) 1 GB RAM
   4) 4 GB Flash Total Storage / 2 GB User Storage
   5) Wi-Fi (Client or WAP)
   6) USB Flash Drive
   7) High Speed Field Bus Expansion
   8) -20 to 60 degrees C Ambient Operating Temperature
   9) Integrated 24 VAC/DC Global Power Supply
   10) MicroSD Memory Card Employing Encrypted Safe Boot Technology

i. The NC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.
j. The NC shall provide alarm recognition, storage, routing, management and analysis to supplement distributed capabilities of equipment or application specific controllers.
k. The NC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via cellular modem, or wide-area network.

l. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:

1) Alarm.
2) Return to normal.
3) To default.

m. Alarms shall be annunciated in any of the following manners as defined by the user:

1) Screen message text.
2) Email of complete alarm message to multiple recipients.
3) Pagers via paging services that initiate a page on receipt of email message.
4) Graphics with flashing alarm object(s).

n. The following shall be recorded by the NC for each alarm (at a minimum):

1) Time and date.
2) Equipment (air handler #, access way, etc.).
3) Acknowledge time, date, and user who issued acknowledgement.

o. Programming software and all controller "Setup Wizards" shall be embedded into the NC.

p. The NC shall support the following security functions:

1) Module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted.
2) Role-Based Access Control (RBAC) for managing user roles and permissions.
3) Require users to use strong credentials.
4) Data in Motion and Sensitive Data at Rest be encrypted.
5) LDAP and Kerberos integration of access management.

q. The NC shall support the following data modeling structures to utilize Search; Hierarchy; Template; and Permission functionality:

1) Metadata: Descriptive tags to define the structure of properties.
2) Tagging: Process to apply metadata to components
3) Tag Dictionary

r. The NC shall employ template functionality. Templates are a containerized set of configured data tags, graphics, histories, alarms... that are set to be deployed as a unit based upon manufacturer's controller and relationships. All lower level communicating controllers (PEC, AUC, AVAV, VFD.) shall have an associated template file for reuse on future project additions.

2. Building Controllers (BCs):

a. Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135 and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.
b. A fully programmable control module capable of storing trends and schedules, serving as a router to devices on a subnet, and initiating read and write requests to other controllers.
c. Capable of serving as a master controller, storing schedules and trends for controllers on a subnet underneath the Building Controller.
d. Trend storage capacity shall be adequate to store trend data of all monitored points, taken at a 15-minute sample frequency for a minimum of 3-months. Trend data shall be downloadable from controller memory for external permanent data storage.

3. Advanced Application Controllers (AACs):

    a. Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135 and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
    b. A fully programmable control module.
    c. Capable of some of the advanced features found in Building Controllers (storing trends, initiating read and write requests, etc.) but it does not required to serve as a master controller.

4. Application Specific Controllers (ASCs):

    a. Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135 and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
    b. A pre-programmed control module intended for use in a specific application.
    c. Configurable, in that the user can choose between pre-programmed options.

5. BACnet Communication:

    a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
    b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
    c. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
    d. Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

C. Communication:

1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
2. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
4. Stand-Alone Operation. Each system specified in Control Sequences shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network such as outdoor air conditions, supply air or water temperature coming from source equipment, etc.

D. Environment. Controller hardware shall be suitable for anticipated ambient conditions.

1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).
2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

E. Keypad. Provide a local keypad and display for each BC and AAC. Operator shall be able to use keypad to view and edit data. Keypad and display shall require password to prevent unauthorized use.

F. Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.

G. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to a field-removable modular terminal strip or to a termination card connected by a ribbon cable. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

H. Memory:

1. Controller memory shall support operating system, database, and programming requirements.
2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
3. Each BC shall have adequate memory to store trend data of all monitored points, taken at a 15-minute sample frequency for a minimum of 3-months. Trend data shall be downloadable from controller memory for external permanent data storage
4. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

I. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

J. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.07 INPUT AND OUTPUT INTERFACE

A. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

B. Protection. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground shall cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no controller damage.

C. Binary Inputs. Binary inputs shall allow the monitoring of ON/OFF signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

D. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall also accumulate up to 10 pulses per second.

E. Analog Inputs. Analog inputs shall monitor low-voltage (0–10 Vdc), current (4–20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

F. Binary Outputs. Binary outputs shall provide for ON/OFF operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on Building Controllers shall have three-position

(on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

G. Analog Outputs. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0–10 Vdc or a 4–20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

H. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

I. System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system

2.08 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

   a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
   b. Line voltage units shall be UL recognized and CSA listed.

B. Power Line Filtering:

1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:

   a. Dielectric strength of 1000 V minimum
   b. Response time of 10 nanoseconds or less
   c. Transverse mode noise attenuation of 65 dB or greater
   d. Common mode noise attenuation of 150 dB or greater at 40–100 Hz.

2.09 DAMPERS

A. General:

1. No single damper shall be larger in size than 48-in in either dimension. Where a larger damper is required, multiple damper assemblies shall be provided.
2. Where multiple damper assemblies are provided, a common actuator may be used to drive a maximum of four dampers. Provide stainless steel connecting linkage as required. Where an assembly is constructed of more than four dampers, multiple actuators shall be provided.
3. Provide quantity, type, size, voltage as scheduled on Drawings.

B. Control Dampers (MCD):

1. Manufacturer:

   a. Greenheck model VCD-33.
   b. Or equal.

2. Ultra low leakage damper.
3. 16 gauge galvanized steel frame. Dampers installed in aluminum or stainless steel duct systems or unducted applications in areas specified to use aluminum or stainless steel ducts shall be provided with Hi-Pro polyester coating or be fabricated of 304 stainless steel frame and blades.
4. Airfoil shaped double skin blades completely symmetrical about the axle pivot point.
5. Blade axles in synthetic sleeve bearings.
6. Silicone blade seals.
7. Flexible stainless steel jamb seals.
8. External (out of the airstream) blade to blade linkage.
9. Suitable for pressures to 8-in. w.c. and velocities to 4,000-fpm with maximum AMCA leakage rate of 6 cfm/sq. ft at 4-in w.c.

C. Insulated Control Dampers (ICD):

1. Manufacturer:

   a. Greenheck model ICD-45.
   b. Or equal.

2. 0.125-in aluminum channel frame insulated with polystyrene on four sides and thermally broken with dual polyurethane resin gaps.
3. Aluminum airfoil blades internally insulated with polyurethane foam and thermally broken.
4. Plated steel axle with dual bearings. Bearings shall have acetal inner sleeve and flanged outer bearing with no metal-to-metal or metal-to-plastic contact.
5. External (out of the airstream) blade to blade linkage.
6. Suitable for pressures to 8-in. w.c. and velocities to 4,000-fpm with maximum AMCA leakage rate of 8 cfm/sq. ft at 4-in w.c.

D. Flow Measuring Control Dampers (FCD):

1. Manufacturer:

   a. Greenheck AMD-42
   b. Ruskin AMS050
   c. Or equal.

2. Integrated airflow monitoring station with flow control damper.
3. Damper:

   a. Ultra low leakage damper.
   b. 16 gauge galvanized steel frame.
   c. Extruded aluminum airfoil shaped double skin blades completely symmetrical about the axle pivot point.
   d. Parallel blade action.
   e. Blade axles in synthetic sleeve bearings.
   f. Stainless steel linkage.
   g. Silicone blade seals.

h. Flexible stainless steel jamb seals.
i. External (out of the airstream) blade to blade linkage.

4. Flow Measurement:

a. 16 gauge galvanized steel sleeve.
b. Aluminum or polycarbonate honeycombed pattern air straightener.
c. Extruded aluminum sensor blades with Total and Static pressure ports.
d. 5% accuracy across measurement range.
e. Controller:

1) 24VAC
2) Shall power modulating damper actuator.
3) Capable of receiving a 0-10V analog airflow setpoint from BAS.
4) Capable of exporting a 0-10V analog airflow feedback to BAS.

E. Damper Actuators:

1. Manufacturer:

a. Belimo
b. Or equal.

2. Actuators shall be adequately sized for the damper size and air pressures anticipated in the system with a safety factor of two.
3. Actuators shall have ISO9001 quality certification and be UL listed under standard 60730-1 or UL listed under standard 873.
4. Actuators used on dampers shall be designed to directly couple and mount to a stem, shaft or ISO style-mounting pad. Actuator mounting clamps shall be a V-bolt with a toothed V-clamp creating a cold weld, positive grip effect. Single point, bolt, or single screw actuator type fastening techniques or direct-coupled actuators requiring field assembly of the universal clamp is not acceptable.
5. Actuators shall be fully modulating/proportional, pulse width, floating/tristate, or two position as indicated in the sequence of operation and be factory or field selectable. Actuators shall have visual position indicators and shall operate in sequence with other devices if required.
6. Provide actuators with end switches or position feedback as indicated in schedules or in the sequences of operation.
7. Actuators shall have an operating range of –22° to 122°F.
8. Proportional actuators shall accept a 0-10 VDC or 0-20 mA input signal and provide a 2-10 VDC or 4-20 mA (with a 500 W load resistor) operating range.
9. Actuators shall be capable of operating on 24 or 120 VAC, or 24VDC and Class 2 wiring as dictated by the application. Power consumption shall not exceed 10 VA for AC, including 120VAC actuators, and 8 watts per actuator for DC applications. Open/Close actuators shall be configured for 120V power supply, modulating actuators shall be configured for 24V power supply.
10. Actuators shall have electronic overload protection or digital rotation sensing circuitry to prevent actuator damage throughout the entire rotation. End switches to deactivate the actuator at the end rotation or magnetic clutches are not acceptable.
11. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Spring return actuators shall be capable of CW or CCW mounting orientation. Spring return models > 60 in-lbs. and non-spring return models > 90 in-lbs. shall be capable of mounting on shafts up to 1.05-in diameter. Spring return actuators with more than 60 in-lb. of torque shall have a metal, manual override crank. Actuators using "on-board" chemical storage systems, capacitors, or other "on-board" non-mechanical forms of fail-safe operation are unacceptable. Upon loss of control signal, a proportional actuator

shall fail open or closed as described below. Upon loss of power, a nonspring return actuator shall maintain the last position.

12. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required. Dampers requiring greater torque or higher close off may be assembled with multiple low torque actuators. Dual mounted actuators using additional anti-rotation strap mechanical linkages, or special factory wiring to function are not acceptable. Actuators in a tandem pair must be "off the shelf," standard actuators ready for field wiring.
13. Damper actuators shall not produce more than 62 dB (A) when furnished with a mechanical fail-safe spring. Non-spring return actuators shall conform to a maximum noise rating of 45 dB(A) with power on or in the running or driving mode.
14. Proportional actuators shall be fully programmable. Control input, position feedback and running time shall be factory or field programmable. Diagnostic feedback shall provide indications of hunting or oscillation, mechanical overload, mechanical travel and mechanical load limit. The actuators shall also provide actuator service data, at minimum, number of hours powered and number of hours in motion.
15. Proportional actuators shall be capable of digital communication, as built.
16. All damper operators shall be oil submerged, geartrain type, inherently positive positioning.
17. The actuators shall be mounted externally of ducts or air handling equipment wherever possible for ease of service and isolated from internal temperatures.
18. Actuator enclosure:

    a. Unless otherwise indicated, NEMA 2.
    b. In areas designated as Class I, Division 1 or 2 hazardous environment, provide explosion proof enclosure.
    c. All process areas (not Mechanical Rooms, in air handling units (AHU) or Administrative Spaces), NEMA 4X.

19. Fail Position:

    a. Outside Air Louvers/Intakes: Closed.
    b. Return Air Dampers: Open.
    c. Duct Mounted Control Dampers: Closed.

2.10 TEMPERATURE SENSORS

A. Temperature Sensors shall be of the type and have accuracy ratings as indicated and/or required for the application and shall permit accuracy rating of within 1% of the temperature range of their intended use. Sensors must be capable of being calibrated.

B. Provide sensors such that the DDC shall be able to convert the resistive input signal available from the element into a digital signal for use by the DDC.

C. All duct sensors shall be electronic resistance type.

D. Sensors used for mixed air application shall be the averaging type of sufficient length to extend diagonally across the entire duct and have an accuracy of 1%.

E. Duct sensors shall protrude into the air stream far enough to sense any temperature differences due to stratification, etc.

F. Outside air sensors shall have a minimum range of -20 °F to 110 °F and an accuracy of within 1 °F in this temperature range. Sensors shall be provided with a water-tight fitting and adequate protection from the effects of solar radiation.

G. Space temperature sensors located in the Office or Electrical Spaces (as defined on Drawing 1-ENV-01) shall have digital space temperature and setpoint display with external setpoint

adjustment and manual Occupied/Unoccupied override. Setpoint adjustment shall be software limited by the operator interface.

H. Space temperature sensors located in process spaces shall be provided with a NEMA 4X enclosure with corrosion resistant elements. Sensors shall have no setpoint adjustment or display. Space temperature setpoint shall be made via the operator interface.

I. Space temperature sensors located in areas identified and Class I, Division 1 or 2 shall be provided with an explosion proof enclosure with corrosion resistant elements. Sensors shall have no setpoint adjustment or display. Space temperature setpoint shall be made via the operator interface.

J. All field mounted sensors shall be labeled in accordance with Section 40 05 10 with the name or identification number used in the control program.

2.11 LOW TEMPERATURE PROTECTION THERMOSTATS

A. Provide low-temperature protection thermostats of manual-reset type with sensing elements 8'-0" or 20'-0" in length.

B. Provide thermostat designed to operate in response to coldest 1'-0" length of sensing element, regardless of temperature at other parts of element.

C. Support element properly to cover entire unit width. Provide separate thermostats for each 25 sq. ft. of coil face area or fraction thereof.

2.12 LINE-VOLTAGE/LOW VOLTAGE ON-OFF THERMOSTATS

A. Bi-metal actuated open contact, or bellows actuated enclosed snap-switch type.

B. UL-listed at electrical rating comparable with application.
C. Heat anticipation.

2.13 LINE VOLTAGE/LOW VOLTAGE THERMOSTATS WITH FAN SWITCH

A. Provide thermostats as described above with three position manual switch labeled Hand-Off-Auto. Switch shall be integral part of thermostat and be capable of mounting on 2-gang switch box.

2.14 CURRENT SENSORS

A. Manufacturer:

1. Automation Components Inc, Model A/SCTA.
2. Or Equal.

B. Split-core type 4-20 mA output current sensor.

C. +12 o 30 VDC sensor supply voltage.

D. 4-20 mA, 2-wire loop powered output.

E. +/- 0.5% accuracy from 0-100% full scale output.

F. 2,200 VAC isolation voltage and upto 600 VAC sensing voltage.

G. Minimum 0.75 inch diameter aperture size.

H. Contactor shall select scale to match equipment served.

2.15 PRESSURE SENSORS

A. Pressure sensor shall be of commercial grade quality located at the point of measurement and installed in accordance with Manufacturer's recommendations.

B. Shall be able to convert the 0-5 VDC input signal available from the sensor into a digital signal for use by the DDC.

C. Ultra precision type with a tolerance at 70°F of no greater than +/- 0.8% of full scale and full scale accuracy of +/-2%.

D. All field mounted sensors shall be labeled in accordance with Section 40 05 10 with the name or identification number used in the control program.

E. Water pressure sensors shall have range of 0-50 psig and be suitable for temperatures to 225°F.

F. Filter differential pressure sensors shall have a range of 0-1 inWC for units with single filters and 0-2 inWC for units with prefilters and carbon filters.

2.16 GAS DETECTION SYSTEMS

A. Manufacturer:

1. RKI Instruments.
2. Or equal.

B. Control Panel:

1. RKI Instruments, Beacon series.
2. Provide control panel with adequate quantity of channels to interface with total number of sensors required plus a minimum of one space channel.
3. NEMA 4X non-metallic panel with hinged cover.
4. 120V power supply.
5. Capable of interfacing with 4-20mA 24VDC, two or three wire transmitters.
6. Panel shall provide power source for all interconnected sensors.
7. Panel shall include a minimum of two relays for each gas alarm, per channel, two relays for common gas alarm, and one relay for common malfunction. All relays shall be fully programmable and rated for minimum 10 amps at 120VAC.
8. Local front of panel display of current value for each connected sensor and push button interface.
9. Suitable for operating temperature range of -4°F to 122°F with 0-99% relative humidity (non-condensing).

C. Sensors:

1. RKI Instruments S2 series, or equal.
2. Infrared sensing technology
3. Configured for Methane (CH4) detection.
4. Capable of measuring 0-100% lower explosive limit (LEL) with Lower Detectable Limit (LDL) within 2% of full scale.
5. Maximum T90 response time of 30 seconds.
6. 24VDC power with maximum 100 mA current draw. 3-wire system.

7. 4-20mA analog output for measured concentration.
8. Cast iron, explosion proof housing, suitable for a Class I, Division 1, Group D hazardous environment.
9. Stainless steel sensing element.
10. Suitable for indoor or outdoor locations with operating temperature range of -40°F to 122°F with 0-99% relative humidity (non-condensing).

2.17 ALARM LIGHTS AND HORNS

A. Manufacturers:

1. Sirena/EEC TWS Series
2. Or equal.

B. Construction:

1. Stacking type alarm light and horn assembly utilizing a common electrical base for installation of up to five modules (lights and horns).
2. 24VDC power supply.
3. NEMA 4 (IP65) assembly rating with lights only, IP24 for assemblies with horns.
4. Suitable for indoor or outdoor locations with operating temperature range of -22°F to 140°F with 0-99% relative humidity (non-condensing).
5. Each light and horn module shall include individual contacts to allow individual activation of each module independent of other modules on the stack.
6. Lights:

a. Continuous LED style.
b. 5 watt maximum per module.
c. Provide Blue color selection for Gas Alarm.
d. Provide Amber color selection for Loss of Ventilation Alarm.

7. Horn:

a. Minimum 76-86 dB at 1 meter.
b. Maximum 6 mA power consumption.

2.18 VENTILATION CONTROL PANELS (VCP-100 and VCP-120)

A. Provide control panels with suitable brackets for either wall or floor mounting where indicated and elsewhere as required. Locate panel as indicated and required.

B. Provide standard NEMA 1 or 12 cabinets of size required to contain temperature controllers; DDC, IDC, and IBC controllers; relays; switches; and similar devices; except limit controllers and other devices excluded in sequence of operations.

C. Each panel containing Building Controller (BC) shall be provided with an LCD touch screen interface installed on the face of the panel.

D. Mount required alarm lights, indicating devices and manual controls on face of panel.

PART 3 – EXECUTION

3.01 GENERAL

A. All necessary equipment, labor, and materials not specifically indicated or specified, but necessary to complete work, are to be provided as part of the Contract.

B. Install all control equipment, accessories, wiring, and piping in a neat and workman like manner. All control devices must be installed in accessible locations.

C. Provide all electrical relays and wiring, line and low voltage, for control systems, devices, and components. All relays and controllers shall be installed in Temperature Control Panels (TCP). All required control power shall be received from TCPs.

D. Control panels serving equipment served by emergency power shall also be served by emergency power.

E. Install system and materials in accordance with manufacturer's instructions and roughing-in drawings, and details on drawings. Install electrical work and use electrical products complying with requirements of applicable Division 26 sections of these specifications. Mount controller at convenient locations and heights.

F. Install "Hand-Off-Auto" selector switches on systems where automatic interlock controls are specified. When switch is in the "Hand" position, allow manual operation of the selected device without the operation of the interlocked motors but allowing unit safety devices to stay in the circuit. When air handling units are in the "Hand" mode, outside air damper shall be open. When fans interlocked with motor operated intake dampers are in the "Hand" mode, associated damper shall open.

3.02 EXAMINATION

A. The Contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.

B. The Contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate or if any discrepancies occur between the plans and the Contractor's work and the plans and the work of others, Contractor shall report discrepancies to the Engineer and shall obtain written instructions for any changes necessary to accommodate Contractor's work with work of others. Any changes in work covered by this Section made necessary by the failure or neglect of the Contractor to report such discrepancies shall be made by and at the expense of, this Contractor.

3.03 PROTECTION

A. Contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.

B. Contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. Contractor shall protect any material that is not immediately installed. Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.04 COORDINATION

A. Site:

1. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, Contractor shall assist in working out space conditions to make a satisfactory adjustment. If Contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, Contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:

1. All communication media and equipment shall be provided as specified in Communication paragraph of this Section.
2. Each supplier of a controls product is responsible for the configuration, programming, start up, and testing of that product to meet the Control Sequences.
3. Contractor shall coordinate and resolve any incompatibility issues that arise between control products provided under this Section and those provided under other sections or divisions of this specification.
4. Contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
5. Contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.05 WORKMANSHIP

A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install equipment in readily accessible locations as defined by National Electrical Code (NEC).

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.06 FIELD QUALITY CONTROL

A. All work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes.

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

C. Contractor shall have work inspection by local and/or state authorities having jurisdiction over the work.

3.07 WIRING

A. All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification. Where the requirements of this Section differ from Division 26, the requirements of this Section shall take precedence.

B. All wiring in mechanical, electrical, or service rooms – or where subject to mechanical damage – shall be installed in raceway at levels below 3 m (10ft).

C. Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

D. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

E. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

F. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.

G. Use color-coded conductors throughout with conductors of different colors.

H. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

I. Conceal all raceways except within mechanical, process, electrical, or service rooms. Install raceway to maintain a minimum clearance of 15 cm (6 inches) from high-temperature equipment (e.g. steam pipes or flues).

J. The contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

3.08 COMMUNICATION WIRING

A. Contractor shall adhere to requirements of Division 26 and items listed in the Wiring paragraph of this Section.

B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

C. Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring.

D. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

E. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.

F. All runs of communication wiring shall be unspliced length when that length is commercially available.

G. All communication wiring shall be labeled to indicate origination and destination data.

H. All communication wiring shall be labeled to indicate origination and destination data.

I. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

J. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:

1. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot.)
2. The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
4. An MS/TP EIA-485 network shall have no T connections.

3.09 SENSOR INSTALLATION

A. Install sensors in accordance with the Manufacturer's recommendations.

B. Mount sensors rigidly and adequately for environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by wall framing.

D. Install all space temperature sensors and thermostats mounted at ADA heights.

E. Any temperature sensor or thermostat mounted on an exterior wall shall be mounted on a thermally insulated sub-base.

F. All wires attached to sensors shall be sealed in their raceways or in the wall to stop air transmitted from other areas from affecting sensor readings.

G. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

H. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1-foot of sensing element for each 1-ft2 of coil area.

I. Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 10-feet downstream.

J. All pipe-mounted temperature sensors shall be installed in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

K. Install outdoor air temperature sensors on north wall, complete with sun shield.

L. Differential Air Static Pressure:

1. Supply Duct Static Pressure. Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the height-pressure tap tubing of the corresponding building

static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
3. Building Static Pressure. Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
5. All pressure transducers shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shut-off valves installed before the tee.

M. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the Control Sequences. Unless indicated otherwise, switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

N. Install humidity sensors for duct mounted humidifiers at least 10-feet downstream of the humidifier. Do not install filters between the humidifier and the sensor.

3.10 ACTUATOR INSTALLATION

A. General. Mount and link control damper actuators according to Manufacturer's instructions.

1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
3. Provide all mounting hardware and linkages for actuator installation.

B. Electric/Electronic:

1. Dampers: Actuators shall be direct mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° travel available for tightening the damper seal. Actuators shall be mounted following Manufacturer’s recommendations.
2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator Manufacturer's recommendations.

3.11 CONTROL DAMPER INSTALLATION

A. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.

B. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure ¼ in. larger than damper dimensions and shall be square, straight, and level.

C. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to

opposite lower corners of each damper section. Both dimensions must be within 0.3 cm (1/8 in.) of each other.

D. Follow the Manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.

E. Install extended shaft or jackshaft according to Manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)

F. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, all sections must open and close simultaneously.

G. Provide a visible and accessible indication of damper position on the drive shaft end.

H. Support ductwork in area of damper when required to prevent sagging due to damper weight.

I. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

3.12 WARNING LABELS

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the control system.

1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows:

C A U T I O N

This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing.

B. Permanent warning labels shall be affixed to all control panels that are connected to multiple power sources utilizing separate disconnects.

1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows.

C A U T I O N

This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

3.13 IDENTIFICATION OF HARDWARE AND WIRING

A. All equipment labeling shall meet the requirements of Section 40 05 10. All wire, cable and raceway labeling shall meet the requirements of Section 26 05 23.

B. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with control system address or termination number.

C. All pneumatic tubing shall be labeled at each end within 2-inches of termination with a descriptive identifier.

D. Permanently label or code each point of field terminal strips to show the instrument or item served.

E. Identify all other control components with permanent labels. All plug-in components shall be labeled such that label removal of the component does not remove the label.

F. Identify room sensors related to terminal boxes or valves with nameplates.

G. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

H. Identifiers shall match record documents.

3.14 CONTROLLERS

A. Provide a separate controller for each AHU or HVAC system as indicated in Control Sequences. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

B. Building Controllers and Custom Application Controllers shall be selected to provide the required I/O point capacity required to monitor all required hardware points.

3.15 CONTROLS COMMUNICATION PROTOCOL

A. General. Electronic controls packaged with this equipment shall communicate with the building direct digital control (DDC) system. The DDC system shall communicate with these controls to read the information and change the control setpoints as shown in the Control Sequences and control schematics. The information to be communicated between the DDC system and these controls shall be in the standard object format as defined in ANSI/ASHRAE Standard 135 (BACnet). Controllers shall communicate with other BACnet objects on the internetwork using the Read (Execute) Property service as defined in Standard 135.

B. Distributed Processing. The controller shall be capable of stand-alone operation and shall continue to provide control functions if the network connection is lost.

C. I/O Capacity. The controller shall contain sufficient I/ O capacity to control the target system.

D. The Controller shall have a physical connection for a laptop computer or a portable operator's tool.

E. Environment. The hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at -40°C to 60°C (-40°F to 140°F).
2. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

F. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field removable, modular terminal strips or to a termination card connected by a ribbon cable.

G. Memory. Controller shall maintain all BIOS and programming information in the event of a power loss for at least 30 days.

H. Power. Controller shall be able to operate at 90% to 110% of nominal voltage rating.

I. Transformer. Power supply for Controller must be rated at minimum of 125% of ASC power consumption and shall be fused or current limiting type.

3.16 PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging.

B. Point Naming. Name points as shown on the equipment points list provided with each sequence of operation. Where multiple points with the same name reside in the same controller, each point name may be customized with its associated Program Object number. For example, "Zone Temp 1" for Zone 1, "Zone Temp 2" for Zone 2.

C. Software Programming:

1. Provide programming for the system and adhere to the specified Control Sequences. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by Contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. Comment statements shall reflect the language used in the Control Sequences. Use the appropriate technique based on the following programming types:

a. Text-based:

1) Must provide actions for all possible situations
2) Must be modular and structured
3) Must be commented

b. Graphic-based:

1) Must provide actions for all possible situations
2) Must be documented

c. Parameter-based:

1) Must provide actions for all possible situations
2) Must be documented.

D. Operator Interface:

1. Standard Graphics. Provide graphics for all mechanical systems and floor plans of the building. This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as setpoints.
2. Contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

3.17 CONTROL SEQUENCES

A. General:

1. All equipment served by the BAS system shall be provided with a means, through the computer interface, to over-ride the automatic controls of unit to manually start or stop the equipment.
2. Each VCP shall include a HVAC Maintenance and HVAC Critical hardwired alarm signal to the Plant PLC:

a. HVAC Maintenance Alarms shall be generated as described below and:

1) Any time space temperature deviates more than 10°F from setpoint.

b. HVAC Critical Alarms shall be generated as described below and:

1) Any time space temperature drops below 35°F.
2) Any time space temperature rises above 104°F.
3) Any time equipment does not run when called.
4) Any interlocked fire alarm shutdown.

3. All measured values, positions and on/off statuses shall be visible on operator interface.
4. Where multiple items serving the same space require thermostatic control, a single space temperature sensor shall be installed to serve all units, unless indicated otherwise.
5. Individual equipment sequences that follow indicate that a controller shall be furnished for each piece of equipment. Contractor shall be permitted to use a single controller and/or input/output interface points for multiple systems to minimize quantity of controllers required.

B. Provide NEMA 1 Temperature Control Panels (VCP-100 and VCP-120). Panel shall house all controllers, shall be source for control power for HVAC control components both field (dampers, etc.) and panel installed, and shall be point of network interface via hard wired connection to Plant PLC. Coordinate 120V power requirements with Division 26.

C. Relays carrying 120V power shall be installed adjacent to the temperature control panel in a separate enclosure. Intent is to separate control voltage and line voltage control components.

D. Electric Control Sequences

1. Stairwell Electric Unit Heaters:

a. Units Served:

1) EUH-100
2) EUH-101.

b. BAS Contractor shall provide and wire NEMA 1 wall mounted thermostat for each electric unit heater. Unit heater fan and electric heating coil shall operate in response to wall mounted thermostat. Upon fall in space temperature below setpoint, 60°F, adjustable, unit fan and electric heater shall energize. Upon satisfaction of space heating requirements, fan shall stop and heater shall de-energize.

E. Digital Control Sequences:

1. Filter Building Electrical Room Cooling and Heating

a. Units Served:

1) RTU-100

b. BAS Contractor shall wire and install wall mounted thermostat furnished with each system. Unit shall operate in response to a Manufacturer furnished wall mounted thermostat.
c. Fan shall be programmed to run continuously.
d. Upon rise in temperature above setpoint 80°F, adjustable, ACU compressor shall energize and vary capacity as required to meet space cooling requirements.
e. Upon fall is space temperature below adjustable setpoint of 65°F, heating coil shall be energized as required to maintain space temperature.
f. Unit BACnet controller shall be connected to building automation system.
g. Initiation of any Economizer FDD Fault codes shall generate a Maintenance Alarm.

2. Makeup Air, Building PFS:

a. Units Served:

1) MAU-100; EF-101,-102,-103,-104; ICD-101,-102.

b. BAS Contractor shall provide DDC controller, ventilation control panel (VCP-100), discharge air temperature sensor, current sensor on each exhaust fan, space temperature sensor, current switch on all lighting circuits for the process areas (all rooms except electrical room, approximately 4 switches required), filter differential pressure transmitter, outside air temperature sensor, control dampers, exhaust fan interlocks, PLC interlocks and other components and wiring as required to meet the sequence of operation.
c. BAS Contractor shall coordinate 120V power supply to ICDs which is work of Division 26. BAS Contractor shall provide control relay.
d. BAS Contractor shall provide Gas Detection System consisting of:

1) Gas Detection Control Panel (GDP-100).
2) Two combustible gas (CH4) detection sensors.
3) All required interlocking and control wiring between GDP and sensors.
4) Panel shall be configured to:

i. Output a single Gas Alarm signal to VCP when measured concentration is within 10% of LEL of CH4 from either sensor.
ii. Output a control Panel Failure Alarm to VCP when trouble or fail condition detected in panel.

e. BAS Contractor shall provide Alarming System consisting of:

1) Four sets of exterior alarm lights (Red and Blue).
2) Two sets of interior alarm lights and horn (Red, Blue, and Horn).
3) All required interlocking and control wiring between GDP, alarm lights, and VCP.
4) Upon indication of Gas Alarm, BAS shall energize all Blue alarm lights and horns. Alarm shall automatically clear upon loss of alarm condition.
5) Upon indication of Loss of Ventilation Alarm (discussed later), BAS shall energize all Amber alarm lights.
6) Upon indication of Loss of Ventilation Alarm (discussed later), BAS shall generate a Critical Alarm.
7) Upon indication of Loss of Ventilation Alarm (discussed later), BAS shall generate a Loss of Ventilation Alarm signal to Plant PLC.
8) Upon indication of Gas Alarm, BAS shall generate a Critical Alarm.
9) Upon indication of Panel Failure Alarm, BAS shall generate a Critical Alarm.

f. Temperature control panel face shall include the following components and labels.

1) Hand-Off-Auto switch: “MAU-100 and EF-101, -102, -103, -104”
2) Green Running Light for each fan: “Running”
3) Amber Light: “Dirty Filter”
4) Red Light: “Loss of Ventilation”

g. In Hand Mode, MAU intake air damper shall open, supply fan shall energize and run continuously at high speed. MAU burner bypass damper shall open. Heating controls shall be locked out. EFs shall energize and run continuously at high speed. ICDs shall open. In the Off Mode, all fans shall remain off and insulated control dampers closed.

h. In the Auto Mode:

1) MAU supply fan shall energize and run continuously at low airflow rate (50% design). MAU burner bypass damper shall close.
2) Insulated control dampers shall open. Upon proof of open, EFs shall energize and run continuously at low speed.
3) EF-3 and EF-4 shall energize and run continuously at low airflow rate.
4) MAU controller shall maintain discharge air temperature setpoint, initially set to 55°F. MAU controller shall modulate rate of fire of burner as required to satisfy discharge air temperature setpoint. BAS shall monitor space temperature, upon fall in space temperature below adjustable setpoint of 55°F, BAS shall reset discharge air temperature setpoint at MAU as required to satisfy space temperature setpoint. Upon rise in space temperature above setpoint, BAS shall reset discharge air temperature setpoint downward to initial setpoint.
5) Under any of the following conditions:

i. Building becomes occupied. Occupancy determined by a current switch on each lighting circuit. If at least 1 current switch shows lighting is energized, the space will be considered occupied.
ii. Gas Alarm as determined from gas detection system.
iii. Outside air temperature greater than 50°F.

The following shall occur to supply maximum outdoor airflow:

i. MAU supply fan shall run continuously at high airflow rate.
ii. MAU burner bypass damper shall open.
iii. EFs shall increase to high airflow rate.

b. Under all modes of operation:

1) BAS shall monitor current draw from each EF motor. Current draw from MAU shall be interfaced with units VFD. Regardless of call to run, if current draw from fan is less than anticipated, Loss of Ventilation Alarm shall be initiated.
2) Running lights on face of VCP shall be activated based upon fan current sensor status, not Hand-Off-Auto switch position.
3) Upon detection that MAU leaving air temperature falls below 35°F (adjustable) fans shall stop. Provide a 3-minute time delay before stop condition is initiated.
4) Filter differential pressure shall be monitored, upon rise in differential pressure above adjustable setpoint, coordinate initial setpoint with MAU manufacturer, a dirty filter light shall illuminate and a Maintenance Alarm shall be generated.

3. Split System Heating and Cooling Units

a. Units Served:

1) ACU-120
2) ACCU-120

b. Related Equipment:

1) ICD-121, MCD-121

c. BAS Contractor shall provide DDC controller, space temperature sensor with digital display and setpoint registration, control wiring between ACU and ACCU, and other components and interlock wiring as required to meet sequence of operation.
d. BAS shall forward space temperature, space temperature setpoints (initially set for 80°F cooling and 65°F heating), and Fan Run command to integral ACU controller. Fan shall be programmed to run at all times.
e. Controller integral to ACU shall enable and control two stage cooling system, single stage heating system, and two-speed fan control as required to satisfy space temperature setpoint. High speed fan operation shall occur whenever second stage of cooling is required and when commanded by Economizer Control.
f. Controller integral to ACU shall interface with BAS to receive fan command, mechanical cooling lock-out, heating lock-out, space temperature setpoints, and high fan speed command.
g. BAS shall monitor the following minimum points from unit mounted controller:

1) Heating status
2) Stage 1 Cooling status
3) Stage 2 Cooling status
4) Discharge air temperature.
5) Fan status
6) Filter status

h. Upon drift in space temperature 5°F above heating setpoint or below cooling setpoint, generate Maintenance Alarm.
i. Upon drift in space temperature 10°F above heating setpoint or below cooling setpoint, generate Critical Alarm.

4. Split System Air Handling Unit Economizer Controls:

a. Units Served:

1) ICD-121, MCD-121

b. Related Equipment:

1) ACU-120, ACCU-120

c. BAS Contractor shall provide DDC controller, outside air temperature sensor, return air temperature sensor, mixed air temperature sensor, insulated control dampers with position feedback, motor operated control damper with position feedback, and other components and interlock wiring as required to meet sequence of operation and International Energy Code Economizer Fault Detection and Diagnostics requirements.
d. System shall utilize common space temperature sensor as ACU-120 and ACCU-120 system.
e. BAS shall monitor outside air temperature, space temperature, and space temperature setpoints:

1) Upon call for space heating, ICD shall remain fully closed and MCD shall remain fully

open.

2) Upon call for cooling with outside air temperature above adjustable setpoint of 55°F, ICD shall remain fully closed and MCD shall remain fully open.
3) Upon call for cooling with outside air temperature below adjustable setpoint of 55°F (Economizer Cycle), BAS shall reset mixed air temperature setpoint as required to maintain space cooling setpoint. BAS shall modulate ICD and MCD in equal and opposite rotations as required to maintain mixed air temperature setpoint with opening of ICD to provide additional cooling.
4) Upon call for mixed air temperature setpoint below 50°F, adjustable, BAS shall command ACU to high speed fan operation. Provide minimum 10 minute time delay between fan speed adjustments.
5) Provide adjustable 15 minute time delay between switching between mechanical and economizer cooling.
6) At any time when Economizer Cycle is active, BAS shall send mechanical cooling and heating lock-out to integral ACU controller to prevent mechanical cooling or heating.
7) Anytime mixed air temperature falls below 40°F (adjustable) and expiration of a 5 minute time delay, BAS shall stop ACU, fully close ICD, fully open MCD, and generate a freezestat and Critical alarm.

f. BAS shall provide status at Operator Interface of the following minimum items. BAS shall monitor applicable points on ACU controller as required to obtain applicable status:

1) Free cooling available
2) Economizer enabled
3) Mechanical cooling enabled
4) Heating enabled
5) Mixed air low limit cycle active
6) Current value of each system sensor

g. BAS shall monitor and alarm at the following minimum faults. Presence of any of these faults shall generate a Maintenance Alarm:

1) Air temperature sensor failure/fault
2) Not economizing when the unit should be economizing
3) Economizing when unit should be economizing
4) Damper not modulating
5) Excess outside air

5. Rooftop Heating and Cooling Unit:

a. Units Served:

1) RTU-120, EF-120, MCD-123, MCD-123, MCD-124.

b. BAS Contractor shall provide DDC controller, unit discharge air temperature sensor, duct discharge pressure sensor, fan speed control interlock, return air humidity sensor, two space temperature sensors (grade and upper level), exhaust fan interlocks, motor control dampers, and other components and wiring as required to meet the sequence of operation. Refer to Section 23 74 19 for item furnished with the unit.
c. BAS system shall control adjustable Occupied/Unoccupied time clock. In the Occupied mode, RTU supply fan and EF-120 shall energize and run continuously and the outside air damper shall open to minimum position (420 CFM). In Unoccupied mode, supply fan shall energize on call for space heat from either space temperature sensor with outside air damper closed and return air damper open, EF-120 shall remain off.

d. Discharge air temperature and Heating Mode or Cooling Mode selection shall be set by the BAS based on summation of calls for heat and cooling from space temperature sensors and outside air temperature:

   1) Whenever outside air temperature is less than 55°F, adjustable, Heating Mode shall be active.
   2) Whenever outside air temperature is above 70°F, adjustable, Cooling Mode shall be active.
   3) When outside air temperature is between Heating and Cooling Mode activation temperatures, system shall be in cooling mode unless a space reaches minimum damper position and space temperature falls an adjustable 3°F below setpoint at which time, Heat Mode shall be activated. Coolest space damper shall fully open and warmest space damper shall close to minimum position. Unit shall remain in Heating Mode until a space is operating at minimum damper position and space temperature rises and adjustable 3°F above space temperature setpoint.
   4) When in Heating or Cooling Mode, RTU discharge air temperature setpoint shall be set as required to maintain space temperature in zone with most open damper at space temperature setpoint.

e. BAS shall monitor space temperature in two zones, grade (MCD-123) and upper level (MCD-122):

   1) When RTU in Heating Mode and space temperature is below setpoint, associated damper shall modulate towards open as required to satisfy space temperature.
   2) When RTU in Heating Mode and space temperature is above setpoint, associated damper shall modulate towards minimum open position as required to satisfy space temperature setpoint.
   3) When RTU in Cooling Mode and space temperature is above setpoint, associated damper shall modulate towards open as required to satisfy space temperature.
   4) When RTU in Cooling Mode and space temperature is below setpoint, associated damper shall modulate towards minimum open position as required to satisfy space temperature setpoint.
   5) When RTU enhanced dehumidification is commanded, dampers shall operate as in Cooling Mode.

f. RTU internal controls shall monitor outside air temperature. On call for cooling with outside air temperature above 55˚F, adjustable, controller shall modulate Lead compressor, stage Lag compressors, and modulate condenser fans as required to meet discharge air temperature setpoint. On call for cooling when outside air temperature is less than 55°F, unit controller shall modulate outside air and return air dampers to maintain setpoint temperature, mechanical cooling shall be locked out.

g. Upon call for heat, unit controller shall energize burner and modulate heating output to maintain discharge air setpoint.

h. When supply fan called to run, BAS shall modulate supply fan speed to maintain duct static pressure setpoint of 1.0 inWC (adjustable). With fan speed and RTU manufacture recommended minimum, BAS shall modulate MCD-124 as required to maintain discharge static pressure. Upon detection of no duct pressure and fan called to run, Critical alarm shall be generated.

i. BAS shall monitor return air relative humidity. Upon rise in humidity above adjustable setpoint of 65%, BAS shall send enable enhanced dehumidification command to RTU.

j. Install return air smoke detector, furnished by Division 16. Coordinate interface with detector and fire alarm panel such that if smoke is detected in the return air or any of the spaces served, supply fan shall stop, outside air damper close, return damper open, EF-120 shall stop, and Critical alarm shall be generated.

k. Upon drop in discharge air temperature below 39°F, adjustable, supply and exhaust fans shall stop, outside air damper shall close, return air damper shall open, and alarm shall be sent.
l. Upon dirty filter signal from RTU, Maintenance alarm shall be generated.

6. Main Pump Building II Lower Level Cooling and Heating

a. Units Served:

1) RTU-121, RF-120

b. BAS Contractor shall wire and install wall mounted thermostat furnished with each system. Unit shall operate in response to a Manufacturer furnished wall mounted thermostat.
c. BAS Contractor shall wire any required interlock for operation of RF-120. BAS shall monitor RTU supply fan feedback and vary speed of RF-120 as required to match RTU supply airflow rate.
d. BAS Contractor shall wire and install return air humidity sensor furnished with equipment. Unit internal controls shall initiate enhanced dehumidification whenever return air humidity rises above an adjustable setpoint of 65%.
e. Fan shall be programmed to run continuously.
f. Upon rise in temperature above setpoint 80°F, adjustable, ACU compressor shall energize and vary capacity as required to meet space cooling requirements.
g. Upon fall is space temperature below adjustable setpoint of 65°F, heating coil shall be energized as required to maintain space temperature.
h. Unit BACnet controller shall be connected to building automation system.
i. BAS Contractor shall coordinate with work of Division 26 the installation of Division 26 furnished return air smoke detector and wiring of alarm contact to RTU fire alarm shutdown.

7. Switch Controlled Exhaust Fan:

a. Equipment Served:

1) EF-121.

b. Coordinate with work of Division 26 to have fan powered through Division 26 furnished, wall mounted On-Off switch.

3.18 CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing. All testing listed in this Section shall be performed by the Contractor and shall make up part of the necessary verification of an operating control system. Testing shall be completed before Owner's representative is notified of the system demonstration.

1. Contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to Manufacturers' recommendations.
4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that normal positions are correct.
5. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. Contractor shall check all

control valves and automatic dampers to ensure proper action and closure. Contractor shall make any necessary adjustments to valve stem and damper blade travel.

6. Verify that system operation adheres to Control Sequences. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops.
7. Alarms and Interlocks:

    a. Check each alarm separately by including an appropriate signal at a value that will trip alarm.
    b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
    c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.19 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration:

1. Prior to acceptance, control system shall undergo a series of performance tests to verify operation and compliance with this specification. Tests shall occur after Contractor has completed the installation, started up the system, and performed his/her own tests.
2. Tests described in this Section are to be performed in addition to the tests that the Contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in Control System Checkout and Testing paragraph of this Section. Engineer may be present to observe and review these tests. Engineer shall be notified at least 10 days in advance of the start of the testing procedures.
3. The demonstration process shall follow process which has been submitted and approved prior to system installation. Approved checklists and forms shall be completed for all systems as part of demonstration.
4. Contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. Purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the Contractor.
5. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
6. Demonstrate compliance with System Performance paragraph of this Section.
7. Demonstrate compliance with Control Sequences through all modes of operation.
8. Demonstrate complete operation of operator interface.
9. Additionally, the following items shall be demonstrated:

    a. DDC loop response. Contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
    b. Interface to the building fire alarm system.
    c. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.

10. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. Contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance:

1. All tests described in this Section shall have been performed to satisfaction of both the Engineer and Owner prior to the acceptance of the control system as meeting requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the Engineer. Such tests shall then be performed as part of the warranty.
2. System shall not be accepted until all forms and checklists completed as part of demonstration are submitted and approved.

3.20 CLEANING

A. Contractor shall clean up all debris resulting from his/her activities daily. Contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At completion of work in any area, Contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At completion of work, all equipment furnished under this Section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.21 TRAINING

A. Provide training for a designated staff of Owner's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.

B. Training shall enable students to accomplish the following objectives:

1. Day-to-day Operators:

a. Proficiently operate the system
b. Understand control system architecture and configuration
c. Understand DDC system components
d. Understand system operation, including DDC system control and optimizing routines (algorithms)
e. Operate the operator interface and peripherals
f. Log on and off the system
g. Access graphics, point reports, and logs
h. Adjust and change system set points, time schedules, and holiday schedules
i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
j. Understand system drawings and Operation and Maintenance manual
k. Understand the job layout and location of control components
l. Access data from DDC controllers and ASCs
m. Operate portable operator's terminals

2. Advanced Operators:

a. Make and change graphics on the workstation
b. Create, delete, and modify alarms, including annunciation and routing of these
c. Create, delete, and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals
d. Create, delete, and modify reports
e. Add, remove, and modify system's physical points
f. Create, modify, and delete programming
g. Add panels when required
h. Add operator interface stations
i. Create, delete, and modify system displays, both graphical and others
j. Perform DDC system field checkout procedures
k. Perform DDC controller unit operation and maintenance procedures
l. Perform workstation and peripheral operation and maintenance procedures
m. Perform DDC system diagnostic procedures
n. Configure hardware including PC boards, switches, communication, and I/O points
o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware
p. Adjust, calibrate, and replace system components

3. System Managers/Administrators:

a. Maintain software and prepare backups
b. Interface with job-specific, third-party operator software
c. Add new users and understand password security procedures

C. Organize the training into sessions or modules for the three levels of operators listed above. (Day-to-Day Operators, Advanced Operators, System Managers and Administrators). Students will receive one or more of the training packages, depending on knowledge level required.

D. Training shall be provided in three separate sessions, each session further divided into the modules described above. Sessions shall be as follows:

1. Initial Training (minimum 4 hours): After system is started up and at least one week before first acceptance test. Manual shall have been submitted at least two weeks prior to training so that the Owners' personnel can start to familiarize themselves with the system before classroom instruction begins.
2. First Follow-Up Training (minimum 4 hours): Approximately four weeks after initial training, and before Formal Acceptance. These sessions will deal with more advanced topics and answer questions.

E. Provide course outline and materials which was submitted and approved a minimum of four weeks prior to scheduling of training. Provide one copy of training material per student.

F. Instructor(s) shall be factory-trained and experienced in presenting this material.

G. Classroom training shall be done using a network of working controllers representative of installed hardware.

3.22 START-UP AND CHECKOUT PROCEDURES

A. Start up, check out, and test all hardware and software and verify communication between all components.

B. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.

1. Verify that all analog and binary input/output points read properly.

2. Verify alarms and interlocks.
3. Verify operation of the integrated system.

END OF SECTION

SECTION 23 11 23
FACILITIES NATURAL GAS PIPING

PART 1 – GENERAL

1.01 SUMMARY

A. Drawings and General Requirements of Contract including General and Supplementary Conditions and Division 01 specification Sections apply to Work of this Section.

B. Extent of natural gas piping system work, is indicated on drawings and schedules, and by requirements of this Section.

C. Applications for natural gas piping systems include the following:

1. Underground site distribution system from existing gas service to new structures
2. Building distribution system from existing gas service to gas-fired equipment connections.

1.02 QUALITY ASSURANCE

A. National Fuel Gas Code Compliance - Comply with applicable provisions of NFPA 54 (ANSI Z223.1) "National Fuel Gas Code", and ANSI Z223.1a "Supplement to National Fuel Gas Code".

B. International Fuel Gas Code (IFGC) by the International Code Council (ICC), Inc.

C. Local Utility Compliance - Comply with requirements of local natural gas utility.

D. Welder's Qualifications:

1. Comply with ASME B31.8.
2. Steel welder shall have a copy of a certified ASME B31.8 qualification test report.
3. Polyethylene welder shall have a certificate from a polyethylene pipe Manufacturer's sponsored training course.

E. Polyethylene Welder's Qualifications:

1. Prior to installation, Contractor shall have supervising and installing personnel trained by a polyethylene pipe Manufacturer's sponsored course or present proof that personnel are currently working in the installation of polyethylene gas distribution lines.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's data for fuel gas piping systems materials and products.

B. Shop Drawings: For pressure regulating valves indicate selected valve size, orifice, and spring range for each required valve and submit valve capacity charts.

C. American Iron and Steel Compliance Certification:

1. This project is being funded by the Clean Water State Revolving Fund that requires that all of the iron and steel products used in the project to be produced in the United States (“American Iron and Steel Requirement”). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R. 3547. These requirements apply to and are

binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.

2. The Manufacturer shall provide with the shop drawing submittal one signed and dated Certification Letter (a sample copies of which are provided in the Appendix). The Certification Letter shall demonstrate compliance with Section 436 of federal H.R. 3547.

D. Submit in accordance with Section 01 33 00.

PART 2 – PRODUCTS

2.01 NATURAL GAS PIPING MATERIALS AND PRODUCTS

A. Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, and capacities as indicated. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in natural gas piping systems. Where more than one type of material or product are indicated, selection is Installer's option.

2.02 BASIC PIPE, TUBE, AND FITTINGS

A. Building Distribution Piping (1 psi and below)

1. Pipe Size 2-inch and Smaller: Black steel pipe, ASTM A53.

a. Pipe Weight: Schedule 40.
b. Fittings: Malleable iron threaded.

2. Pipe size 2-1/2-inch and Larger: Black Steel Pipe.

a. Pipe weight: Schedule 40.
b. Fittings: Wrought-steel butt welding.

B. Building Distribution Piping (Above 1-psi)

1. Pipe size 1-1/2-inch and smaller: Black Steel Pipe.

a. Pipe weight: Schedule 40.
b. ASTM A53.
c. Fittings: Forged steel, socket weld, meeting requirements of ASTM B16.11.

2. Pipe size 2-inch and Larger: Black Steel Pipe.

a. Pipe weight: Schedule 40.
b. ASTM A53.
c. Fittings: Wrought-steel butt welding.

C. Underground Distribution Piping

1. Pipe size 6” and smaller:

a. High Density Polyethylene conforming to PE Grade 4710 as per ASTM F714.
b. Manufactured and testing is accordance with ASTM D2513.
c. Minimum Dimension Ratio: SDR11.
d. Cell Classification: PE 445474 C or higher.
e. Piping shall be provided with service identification stripe coextruded with the pipe and of the same material as pipe.

f. Fittings shall be polyethylene molded heat fusion type, manufactured with PE 4710 and in accordance with ASTM D2513
g. Fittings and joints shall have long-term pressure capabilities equal to or greater than the pressure/vacuum rating of the pipe.
h. All buried natural gas valve shall be Type V370 in accordance with Section 40 05 53.

D. Anodeless Risers:

1. Manufacturers:

a. GF Piping Systems.
b. Elster Perfection.
c. Continental Industries.

2. General:

a. Custom factory bent anodeless riser providing transition from HPDE buried gas piping to steel above grade piping resulting in a joint stronger than the connecting HDPE piping.
b. All metallic gas piping shall be sealed within casing and adequately protected to allow installation without supplemental cathodic protection.
c. Built to suit proposed gas pipe bury depth, no less than 1'-6" below grade, with above grade termination located at 1'-0" above finished grade.
d. Plain end below grade HDPE connection.
e. Butt weld or threaded above grade end connection as dictated by applicable Building Distribution Piping paragraph.

3. Construction:

a. Fitting shall meet the requirements of Mechanical Fittings within ASTM D2513, Category 1.
b. All gas carrying steel components shall be fabricated of ASTM A53 steel. Minimum pipe weight of Schedule 40.
c. All gas carrying polyethylene pipe and tubing shall conform to ASTM D2513.
d. Casing materials shall meet or exceed requirement of ASTM A513.
e. All steel components shall be electrostatically coated with a polyester or epoxy coating.

E. Flexible Pipe Connector:

1. Manufacturer:

a. Metraflex series GASC.
b. Or equal.

2. UL or CSA listed flexible pipe connector for natural gas service, suitable for outdoor installation.
3. Corrugated 300 series stainless steel hose and braid.
4. Schedule 40 carbon steel fittings.
5. Butt weld or threaded above grade end connection as dictated by applicable Building Distribution Piping paragraph.
6. Listed for working pressure up to 150 psig.
7. Capable of absorbing a minimum of 2 inches of piping offset between centerlines of connecting pipes.

2.03 VALVES

A. Provide valves meeting the requirements of Section 40 05 53 and as follows:

1. Equipment/Building Isolation, 2 inch and larger: Type V025.
2. Buried Isolation Valves: Type V370.
3. Equipment Isolation, 1-1/2 inch and smaller: Type V382.
4. Pressure Regulating (150 to 1,000 SCFH): Type V707

2.04 BASIC SUPPORTS, ANCHORS, AND SEALS

A. Provide supports, anchors, and seals complying with local Fuel Gas Code, Section 40 05 07, in accordance with the following listing:

1. Clevis hanger or band hangers for horizontal-piping.
2. Two-bolt riser clamps for vertical piping supports.
3. Concrete anchors and clamps for building attachments.
4. Piping indicated to be routed above the roof structure shall be supported with non-penetrating roof supports.

B. Material shall be in accordance with Section 40 05 07 with respect to the “Environment” the piping support systems are installed as indicted on Project Space Environment/Hazardous Rating Schedule found in the 001 series of Drawings.

PART 3 – **EXECUTION**

3.01 INSTALLATION OF NATURAL GAS PIPING

A. Install natural gas distribution piping in accordance with applicable codes and local utility company requirements.

B. Use sealants on metal gas piping threads which are chemically resistant to natural gas. Use sealants sparingly, and apply to only male threads of metal joints.

C. Remove cutting and threading burrs before assembling piping.

D. Do not install defective piping or fittings. Do not use pipe with threads which are chipped, stripped or damaged.

E. Plug each gas outlet, including valves, with threaded plug or cap immediately after installation and retain until continuing piping, or equipment connections are completed.

F. Ground gas piping electrically and continuously within project, and bond tightly to grounding connection.

G. Install drip-legs in gas piping where indicated, and where required by code or regulation.

H. Install "Tee" fitting with bottom outlet plugged or capped, at bottom of pipe risers.

I. All branch connections shall be made horizontal from or vertically upward from main piping.

J. Install piping with 1" drop in 60' pipe run (0.14%) in direction of flow.

K. Install piping parallel to other piping.

L. All gas piping in concealed locations such as ceiling plenums shall have welded joints.

M. Vent all interior regulators to the building exterior. Vent termination shall be located a minimum of 10'-0" away from any outside air intake and 5'-0" from any combustion exhaust outlet.

N. Paint gas piping yellow after all testing is complete in accordance with Section 09 96 00. Confirm final color selection with Owner prior to coating.

O. Label piping in accordance with Section 40 05 97.

P. Do not install polyethylene gas pipe inside buildings.

Q. Underground Piping:

1. All joints in underground polyethylene gas pipe must be made by qualified personnel proficient in the joining methods of ASTM D2513 thermoplastic gas pressure pipe and polyethylene fittings.
2. All underground piping shall be installed with electrically continuous type TW insulated number 12 tracer wire in the trench along with the pipe, fastened to pipe at 20 foot intervals terminating above ground at each riser.
3. All transitions between underground polyethylene gas pipe and above ground steel gas piping shall be made with an anodeless riser.

3.02 GAS SERVICE

A. Schedule any interruptions of existing gas service with Owner.

3.03 INSTALLATION OF SUPPORTS, ANCHORS, AND SEALS

A. Install supports, anchors, and seals in accordance with Local Fuel Gas Code and Section 40 05 07.

3.04 INSTALLATION OF VALVES

A. Install valves meeting the requirements of Section 40 05 53 and as follows:

1. Provide gas cocks at connection to gas train for each gas-fired equipment item; and on risers and branches where indicated.
2. Locate gas cocks where easily accessible, and where they will be protected from possible injury.

3.05 INSTALLATION OF PRESSURE REGULATORS

A. Install pressure regulators where indicated in accordance with manufacturer's instructions.

B. Regulators installed indoors shall be vented to outdoors.

3.06 EQUIPMENT CONNECTION

A. Connect gas piping to each gas-fired equipment item, with drip leg, union or flange, pressure regulating valve (where required), and shutoff gas cock. Comply with equipment Manufacturer's instructions.

B. All connections to outdoor, concrete pad mounted equipment and other locations where specifically indicated, shall include a flexible pipe connector.

1. This connector shall be located downstream of isolation valve.

2. For equipment fed by buried gas piping, flexible connector shall be installed between point of existing ground and first pipe support on concrete equipment pad.
3. For equipment fed by building supported above-grade gas piping, flexible connector shall be installed between last building support and first pipe support on concrete equipment pad.

C. Site gas distribution systems operates at a nominal 5 psi. Any natural gas fueled component that is not suitable for stated distribution pressure shall be provided with pressure reducing valve, sized for equipment flow rate and selected to reduce pressure from distribution pressure to maximum allowable pressure of equipment served.

3.07 PIPING TESTS

A. Test natural gas piping in accordance with ANSI B31.2 or other recognized testing procedure.

END OF SECTION

SECTION 23 23 00
REFRIGERANT PIPING SYSTEMS

PART 1 - GENERAL

1.01 SUBMITTALS

A. Submittal Information:

1. Product Data: Submit manufacturer's technical product data and installation instructions for refrigerant piping materials and products.
2. Shop Drawings: Submit scaled layout drawings of refrigerant pipe and fittings including, but not necessarily limited to, pipe and tube sizes, locations, elevations, and slopes of horizontal runs, walls and floor penetrations, and connections. Show interface between piping and equipment.
3. Shop Drawings, Wiring Diagrams: Manufacturer's ladder type for interlock and control wiring. Clearly differentiate between portions of wiring factory-installed and portions to be field-installed.

B. Submit in accordance with Section 01 33 00.

C. Information submitted by Contractor, but not designated to be submitted will be returned without action by Engineer.

1.02 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of refrigerant piping products of types, materials, and sizes required whose products have been in satisfactory use in similar service for not less than 3 yrs.

B. Installer's Qualifications: Firm with at least 3 yrs successful installation experience on projects with refrigerant piping work similar to that required for Project.

C. Regulatory Requirements:

1. ASME Compliance: Fabricate and install refrigerant piping in accordance with ASME B31.5 and extend applicable lower pressure limits to pressures below 15 psig.
2. UMC Compliance: Fabricate and install refrigerant piping in accordance with ICBO "Uniform Mechanical Code."
3. ASHRAE Compliance: Fabricate and install refrigerant piping in accordance with ASHRAE 15.

PART 2 - PRODUCTS

2.01 GENERAL

A. Contractor shall furnish and install all refrigerant specialties recommended by Manufacturer of equipment served.

2.02 MANUFACTURERS

A. Manufacturer's equipment used as basis of design for Project is name indicated in Specification for particular type of equipment or application contained in these Contract Documents. If no manufacturer is listed, basis of design is industry standard indicated.

2.03 MATERIALS

A. Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Contractor to comply with installation requirements. Provide materials and products complying with ASME B31.5 where applicable, base pressure rating on refrigerant piping system maximum design pressures. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in refrigerant piping systems. Where more than one type materials or products indicated, selection is Contractor's option.

B. Provide insulation in accordance with Section 23 07 00.

2.04 BASIC IDENTIFICATION

A. Comply with Section 40 05 97 and in accordance with following:

1. Refrigerant Piping: Plastic pipe markers.

2.05 PIPES AND PIPE FITTINGS

A. Construct piping systems of the in accordance with the following:

1. Tube Size 4 1/8 in. and Smaller: Copper tube; Type ACR, hard-drawn temper; wrought copper, solder joint fittings; soldered joints.
2. Soldered Joints: Solder joints using silver-lead solder, ASTM B32, Grade 96 TS.
3. Brazed Joints: Braze joints using AWS classification BCuP-4 for brazing filler metal.

2.06 SUPPORTS AND ANCHORS

A. Comply with Section 40 05 07 and in accordance with following:

1. Adjustable steel clevises, adjustable roller hangers, and adjustable pipe roll stands for horizontal piping hangers and supports.
2. 2-bolt riser clamps for vertical piping supports.
3. Concrete inserts, C-clamps, and steel brackets for building attachments.
4. Protection shields for insulated piping support in hangers.
5. Copper flashings for piping penetrations.

2.07 SPECIAL REFRIGERANT VALVES

A. Globe and Check Valves:

1. Manufacturers:

a. Henry Valve Company.
b. Parker Hannifin Corporation, Refrigeration and Air Conditioning Division.
c. Sporlan Valve Company.
d. Or equal.

2. Globe Shutoff Valves: Forged brass, packed, back seating, winged seal cap, 300°F (149°C) temperature rating, 500 psi working pressure.
3. Check Valves: Forged brass, accessible internal parts, soft synthetic seat, fully guided brass piston and stainless steel spring, 250°F (121°C) temperature rating, 500 psi working pressure.

B. Solenoid Valves:

1. Manufacturers:

a. Alco Controls, Division of Emerson Electric Company.
b. Automatic Switch Company.
c. Sporland Valve Company.
d. Or equal.

2. 2-Way Solenoid Valves: Forged brass, designed to conform to ARI 760, normally closed, teflon valve seat, NEMA 1 solenoid enclosure, 24 v, 60 Hz, UL-listed, 1/2 in. conduit adapter, 250°F (121°C) temperature rating, 400 psi working pressure.

a. Manual Operator: Provide manual operator to open valve.

2.08 REFRIGERANT SPECIALTIES

A. Manufacturers:

1. Alco Controls, Division of Emerson Electric Company.
2. Henry Valve Company.
3. Parker-Hannifin Corporation, Refrigeration and Air Conditioning Division.
4. Sporlan Valve Company.
5. Or equal.

B. Refrigerant Strainers: Brass shell and end connections, brazed joints, monel screen, 100 mesh, UL listed, 350 psi working pressure.

C. Moisture-Liquid Indicators: Forged brass, single port, removable cap, polished optical glass, solder connections, UL-listed, 200□F (93□C) temperature rating, 500 psi working pressure.

D. Refrigerant Filter Dryers: Corrosion-resistant steel shell, steel flange ring and spring, wrought copper fittings, ductile iron cover plate with steel cap screws, replaceable filter dryer core, 500 psi working pressure.

E. Evaporator Pressure Regulators: Provide corrosion-resistant, spring loaded, stainless steel springs, pressure operated, evaporator pressure regulator in size and working pressure indicated, with copper connections.

F. Refrigerant Discharge Line Mufflers: Provide discharge line mufflers recommended by equipment manufacturer for use in service indicated, UL listed.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which refrigerant piping system materials and products to be installed. Do not proceed with Work until unsatisfactory conditions are corrected.

3.02 INSTALLATION OF BASIC IDENTIFICATION

A. Comply with Section 40 05 97.

3.03 INSTALLATION OF REFRIGERANT PIPING

A. Install refrigerant piping in accordance with equipment manufacturer's recommendations.

B. Install refrigerant piping with slope as recommended by manufacturer. Provide oil traps and double risers where required by ASHRAE and recommended by equipment Manufacturer to provide oil return.

C. Clean refrigerant piping by swabbing with dry lintless (linen) cloth, followed by refrigerant oil soaked swab. Remove excess oil by swabbing with cloth soaked in high flash point petroleum solvent, squeezed dry.

D. Bleed dry nitrogen through refrigerant piping during brazing operations.

E. Insulation in accordance with Section 23 07 00.

3.04 INSTALLATION OF SUPPORTS AND ANCHORS

A. Comply with Section 40 05 07.

3.05 INSTALLATION OF SPECIAL REFRIGERANT VALVES

A. Install refrigerant valves where indicated and in accordance with manufacturer's instructions. Remove accessible internal parts before soldering or brazing and replace after joints complete.

B. Solenoid Valves: Install in refrigerant piping as indicated with stem pointing upwards.

1. Wiring of solenoid valves is specified in applicable Division 23 Sections and is not Work of this Section.

3.06 INSTALLATION OF REFRIGERANT ACCESSORIES

A. Refrigerant Strainers: Install in refrigerant lines in accessible location for service.

B. Moisture-Liquid Indicators: Install on refrigerant liquid lines in accessible location.

C. Refrigerant Filter Dryers: Install in refrigerant lines in accessible location for service.

D. Evaporator Pressure Regulators: Install in refrigerant suction lines or evaporator outlets. Adjust, if required, for proper evaporator pressure.

E. Refrigerant Discharge Line Mufflers: Install in horizontal or downflow portion of hot gas lines immediately after leaving compressor, not in riser.

3.07 EQUIPMENT CONNECTIONS

A. Connect refrigerant piping to mechanical equipment in accordance with equipment manufacturer's instructions where not otherwise indicated.

3.08 DEHYDRATION AND CHARGING SYSTEM

A. Install core in filter dryer after leak test but before evacuation.

B. Evacuate refrigerant system with vacuum pump until temperature of 35°F (2°C) indicated on vacuum dehydration indicator.

C. During evacuation, apply heat to pockets, elbows, and low spots in piping.

D. Maintain vacuum on system for minimum of 5 hrs after closing valve between vacuum pump and system.

E. Break vacuum with refrigerant gas and allow pressure to build up to 2 psi.

F. Complete charging of system, using new filter dryer core in charging line. Provide full operating charge.

3.09 FIELD QUALITY CONTROL

A. Refrigerant Piping Leak Test: Prior to initial operation, clean and test refrigerant piping in accordance with ASME B31.5. Perform initial test with dry nitrogen, using soap solution to test all joints. Perform final test with 27 in. vacuum, then 200 psi using halide torch. System shall be entirely leak-free.

B. Repair or replace refrigerant piping as required to eliminate leaks and retest as specified to demonstrate compliance.

END OF SECTION

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SECTION 23 31 13
METAL DUCTS

PART 1 – GENERAL

1.01 SUMMARY

A. Drawings and General Requirements of contract including General and Supplementary Conditions and Division 01 specification Sections apply to work of this Section.

B. Extent of ductwork is indicated on drawings and in schedules, and by requirements of this Section.

C. Types of ductwork required for project include the following:

1. Air conditioning supply and return air systems.
2. Fresh air supply systems.
3. OA exhaust systems.
4. Mechanical exhaust systems.

1.02 SUBMITTALS

A. General:

1. Submit Product Data and Shop Drawings in sufficient detail to confirm compliance with requirements of this Section. Submit Product Data and Shop Drawings in one complete submittal package. Partial submittals are unacceptable.

B. Shop Drawings:

1. Dimensioned layouts of ductwork showing accurately scaled ductwork, support requirements, and their relation to space enclosure. Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure free area, materials, and rigidity is not reduced.
2. Duct layout indicating pressure classification and sizes on plans.
3. Seam and joint construction.
4. Penetrations through fire-rated and other partitions.
5. Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.

C. Product Data:

1. Manufacturer's specifications for duct system materials showing dimensions, thicknesses, weights, materials of construction, corrosion resistance characteristics, and method of construction.

D. American Iron and Steel Compliance Certification:

1. This project is being funded by the Clean Water State Revolving Fund that requires that all of the iron and steel products used in the project to be produced in the United States (“American Iron and Steel Requirement”). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R. 3547. These requirements apply to and are binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.

2. The Manufacturer shall provide with the shop drawing submittal one signed and dated Certification Letter (a sample copies of which are provided in the Appendix). The Certification Letter shall demonstrate compliance with Section 436 of federal H.R. 3547.

E. Submit in accordance with Section 01 33 00.

1.03 QUALITY ASSURANCE

A. Installer: Firm with at least 3 yrs successful installation experience on projects with ductwork systems work similar to that required for Project.

B. NFPA Compliance - Comply with ANSI/NFPA 90A "Standard For The Installation Of Air Conditioning And Ventilating Systems" and ANSI/NFPA 90B "Standard For The Installation Of Warm Air Heating And Air-Conditioning Systems".

C. Underwriters Laboratories - UL 181 - Factory-Made Air Ducts and Connectors.

D. Design Criteria:

1. Construct all ductwork to be free from vibration, chatter, objectionable pulsations and leakage under specified operating conditions.
2. Use material, weight, thickness, gauge, construction and installation methods as outlined in the following SMACNA publications, unless noted otherwise:

a. HVAC Duct Construction Standards, Metal and Flexible.
b. HVAC Air Duct Leakage Test Manual.
c. HVAC Systems - Duct Design.
d. Rectangular Industrial Duct Construction Standard.
e. Round Industrial Duct Construction Standards.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings.

B. Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclose with waterproof wrapping.

PART 2 – PRODUCTS

2.01 DUCTWORK MATERIALS

A. General: All ductwork shall be constructed of non-combustible or conforming to requirements for Class 0 or 1 air duct materials, or UL 181.

B. Exposed Ductwork Materials - Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains and discolorations, and other imperfections, including those which would impair painting.

C. Sheet Metal:

1. Galvanized Sheet Steel - ANSI/ASTM A 527, lockforming quality, with ANSI/ASTM A 525, G90 zinc coating; mill phosphatized for exposed locations.
2. Aluminum Sheet - ANSI/ASTM B209 aluminum sheet, alloy 3003H-14. Aluminum

Connectors and Bar Stock: Alloy 6061-T6 or of equivalent strength.

D. Ductwork Material Selection

1. All ductwork, unless indicated otherwise on the Drawings or below, shall be constructed of aluminum.
2. Ductwork within Old Main Pump II ductwork shall be galvanized steel.
3. Odorous air ductwork shall be FRP in accordance with specification 23 31 16.

2.02 MISCELLANEOUS DUCTWORK MATERIALS

A. Duct Sealant: Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic.

B. Ductwork Support Materials and Fasteners: Provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of galvanized steel ductwork. Provide 316 stainless steel fasteners, anchors, rods, straps, trim and angles for support of stainless steel or aluminum ductwork.

2.03 FABRICATION - GENERAL

A. Fabricate ductwork of gauges and reinforcement complying with SMACNA Duct Construction Standards and ASHRAE handbooks for 2-In. W.C. Pressure Class.

B. Ductwork shall be constructed to provide the minimum clear inside dimensions indicated on the Drawings.

C. All ductwork specified to be of welded construction shall be a minimum 18 gauge sheet metal thickness.

D. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with centerline radius 1.5 times the associated duct width; and fabricate to include airfoil turning vanes in elbows where shorter radius is necessary. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.

E. Construct so that all interior surfaces are smooth. Use slip and drive or flanged and bolted construction when fabricating rectangular ductwork. Use spiral lock seam construction when fabricating round spiral ductwork. Sheet metal screws may be used on duct hangers, transverse joints and other SMACNA approved locations if the screw does not extend more than 1/2 inch into the duct.

F. Limit angular tapers to 30°(for contracting tapers and expanding tapers).

G. Provide expanded take-offs or 45 degree entry fittings for branch duct connections with branch ductwork airflow velocities greater than 700 fpm. Square edge 90-degree take-off fittings or straight taps will not be accepted.

H. Button punch snaplock construction will not be accepted on aluminum ductwork.

I. When approved by the Engineer, size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts. No variation of duct configuration or sizes permitted except by written permission.

J. Provide easements where low pressure ductwork conflicts with piping and structure. Where easements exceed 10 percent duct area, split into two ducts maintaining original duct area.

K. Use double nuts and lock washers on threaded rod supports.

L. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible. Refer to Section 23 33 00, for accessory requirements.

M. Round Ductwork:

1. Spiral lockseam or longitudinal welded seam as manufactured by United McGill Sheet Metal Company. Models Uniseal, Unicoat, or Longitudinal Seam.
2. Minimum sheet metal gauges, hanger spacing, and reinforcement shall be per SMACNA HVAC Duct Construction Standards - Metal and Flexible for pressures from negative 4" w.g. up to positive 10" w.g. For pressures less than negative 4" w.g., or greater than positive 10" w.g., minimum sheet metal gauges, hanger spacing, and reinforcement shall be per SMACNA Round Industrial Duct Construction Standards.
3. Fittings: Fittings shall have a wall thickness not less than that required for longitudinal-seam straight duct.
4. Elbows:

a. Elbows for round ducts shall have a minimum centerline radius of 1-1/2 times the diameter of the duct and shall be constructed without splitters.
b. Smooth or stamped elbows shall be used whenever possible.
c. When gored elbows are used they shall be constructed as follows: Elbows up to 36° shall have 2 gores, 37° through 72° shall have 3 gores, and 73° through 90° shall have 5 gores.
d. Four gore adjustable elbows are permitted for systems rated at 1 in. w.g. or less. The gores shall be tack welded or coated with sealer on diameters from 8" to 14". Diameters above 14" shall be tack welded.

2.04 DUCT SEALANTS

A. Manufacturers:

1. Ductmate Industries
2. 3M.
3. H.B. Fuller/Foster.
4. Or equal.

B. Shall be a flexible, water-based, adhesive sealant designed for use in all pressure duct systems. After curing, it shall be resistant to ultraviolet light and shall prevent the entry of water, air, and moisture into the duct system. Sealer shall be UL 723 listed and meet NFPA requirements for Class 1 ductwork. VOC shall be <75 g/l.

C. Select sealant color to generally match color of ductwork material.

D. Sealants used on ductwork indicated to receive field painting shall be suitable for painting.

E. Install sealants in strict accordance with manufacturer's recommendations, paying special attention to temperature limitations. Allow sealant to fully cure before pressure testing of ductwork, or before startup of air handling systems.

2.05 GASKETS

A. For 2-Inch Pressure Class and lower, provide soft neoprene or butyl gaskets in combination with duct sealant for flanged joints.

PART 3 – EXECUTION

3.01 INSTALLATION OF DUCTWORK

A. Provide ductwork insulation in accordance with Section 23 07 00.

B. Assemble and install ductwork to achieve SMACNA seal Class B and noiseless (no objectionable noise) systems. Install each run with minimum of joints.

C. A rigid ductwork support or form of lateral bracing shall be provided at each change in ductwork directions, each end of run and elsewhere as noted on Drawings to minimize ductwork sway to no more than ½-inch of total travel.

D. Pittsburgh lock seams and slip joints or ductmate shall be used for all rectangular ducts.

E. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth.

F. Coordinate ductwork layout with lighting, suspended ceilings, piping, and structural components.

G. Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible.

H. Locate runs as indicated by diagrams, details, and notations. Ensure ductwork does not obstruct usable space or block access for servicing building and its equipment.

I. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Limit clearance to 1/2" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1" clearance outside of insulation.

J. Pitch outside air intake ductwork toward intake to allow drainage to building exterior.

K. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

L. Where ducts pass through interior partitions and exterior walls, conceal space between construction opening and duct or duct-plus-insulation with sheet metal flanges of same gauge and material as duct. Overlap opening on 4 sides by at least 1-1/2 inches.

M. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire damper, sleeve, and fire stopping sealant.

N. Coordinate duct installations with installation of accessories, dampers, equipment, controls and other associated work of ductwork system.

O. Sealant shall be pumped or painted into joints, as required, after assembly. Sealant shall be allowed to set for 48 hours before any air pressure is put on system. All tie bars, bolts and rivets shall be sealed with the specified sealant.

P. Install sealants in strict accordance with manufacturer's recommendations, paying special attention to temperature limitations. Allow sealant to fully cure before pressure testing of ductwork, or before startup of air handling systems.

Q. All ductwork shall be airtight before concealment and/or before insulation is applied.

R. All tie rods shall be 3/8" dia. When one tie rod is required, it shall be installed in the center of the duct. When two tie rods are required, installation shall be at 1/3 points across ducts. When three tie rods are required, installation shall be at 1/4 points across ducts. Where tie rods are required in the horizontal and vertical side, they shall be welded together where they cross. All tie rods shall be welded to reinforcing angles or joints

S. Install concrete inserts for support of ductwork in coordination with formwork.

T. Support ductwork in manner complying with SMACNA "Duct Construction Standards - Metal and Flexible"- Latest Edition hangers and supports section.

U. Where dissimilar metals meet, provide positive electric isolation using insulating material, sealants, and fasteners.

3.02 DUCT OBSTRUCTIONS

A. Install streamlined metal sleeve around any obstruction which must run through ducts with approval by the Engineer only.

B. Sleeves to have rounded noses on upstream face and tapered back to point on downstream side of obstructions. Sleeves to extend completely between walls of duct and be firmly riveted in place.

3.03 PIPE SEALS

A. All openings around pipes thru sheet metal ducts, casings, or other sheet metal surfaces shall be sealed and made air tight by this Contractor.

B. Seal shall consist of 1/4" thick split felt gasket tightly fitted around pipe and held in place with either a split rigid steel ring or a Crane No. 20 chrome-plated split floor plate drilled and bolted to the sheet metal surface.

3.04 INSTALLATION OF AUTOMATIC DAMPERS

A. Install all automatic dampers furnished by and under the supervision of the automatic temperature control manufacturer.

B. All blank-off plates and conversions necessary to install smaller than duct size dampers shall be the responsibility of the ductwork installer.

C. The Temperature Controls Contractor, as work of Section 23 09 23, shall submit a schedule of damper sizes to the ductwork installer, with a copy to the Engineer.

3.05 LOUVERS AND BLANK-OFF PANELS

A. Outdoor air intake and exhaust louvers are specified under other sections. Where ductwork indicated to be connected to louver, provide 1-1/2" x 1-1/2" x 1/4" aluminum or galvanized steel angle frames to match ductwork all around the louver openings securely bolted to construction with mastic caulking compound between angle and construction. Ductwork, casings, etc., shall be riveted to the outstanding leg of angle frames.

B. Blank-off panels, where required, shall be provided under this Section of the Specifications. Panels shall be of double wall aluminum construction with central layer of 2-inch thickness of

polyisocyanurate board insulation.

C. Where louvers contain gravity or motor operated dampers and are shown to be non-ducted, provide No. 2 (1/2" mesh) 0.063" dia. aluminum bird screens with rewirable and removable extruded aluminum frames or aluminum expanded metal on the interior face of damper installed to not interfere with damper operation.

3.06 CAULKING AND TAPING

A. Caulk all joints, rivets, flanges, flexible connections, filter frames, openings, seams, etc.

B. Caulk all casings airtight.

C. Caulking shall be 3M No. EC-800 premium grade.

D. Where pressure testing indicates a leak that caulking has not sealed, provide a sheet metal jacket over the seam or joint and weld in place. Weldments to be continuous.

3.07 CLEANING AND PROTECTION

A. Clean ductwork internally, unit-by-unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.

B. At ends of ducts which are not connected to equipment or any distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

END OF SECTION

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SECTION 23 31 14
NON-FIBROUS, CLOSED CELL, OUTDOOR DUCTWORK

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Factory insulated, outdoor ductwork systems.

1.02 SUBMITTALS

A. General:

1. Submit Product Data in sufficient detail to confirm compliance with requirements of this Section. Submit Product Data and Shop Drawings in one complete submittal package. Partial submittals are unacceptable.

B. Product data: For each type of product indicated.

C. Shop drawings: Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work including.

1. Duct layout indicating sizes and pressure classes.
2. Elevation of top of ducts.
3. Dimensions of main duct runs from building grid lines.
4. Fittings.
5. Penetrations through fire-rated and other partitions.

D. Coordination Drawings: Plans, drawn to scale, showing coordination general construction, building components, and other building services.

E. Manufacturer's field installation inspection report.

F. Submit in accordance with Section 01 33 00.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firms experienced in manufacturing phenolic ductwork systems meeting the requirement of SMACNA's Phenolic Duct Construction Standard for no less than 3 years.

1.04 PRODUCT DELIVERY AND STORAGE

A. Prevent objectionable aesthetic damage to the outer surface of duct segments during transport and storage.

B. Store duct segments under cover and protect from excessive moisture prior to installation.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is made safe from such hazards.

PART 2 – PRODUCTS

2.01 RECTANGULAR DUCT AND FITTINGS

A. MANUFACTURERS

1. Thermaduct.
2. Or equal.

B. Requirements:

1. Duct Leakage Class, follow SMACNA Leakage Class 3 or less.
2. Fortified inner liner shall be compliant to UL (C-UL) 181 Standard for Safety Listed, Class 1 system, with included testing and passing the following:

a. Test for Surface Burning Characteristics
b. Flame Penetration Test
c. Burning Test
d. Mold Growth and Humidity Test
e. Low Temperature Test and High Temperature Test
f. Puncture Test
g. Static Load Test
h. Impact Test
i. Pressure Test and Collapse (negative pressure) Test
j. High Temperature and Humidity for 90 days
k. Cone Calorimeter
l. ASTM E2257 Standard Test Method for Room Fire Test of Wall and Ceiling Materials and Assemblies
m. ASTM E 84 tested, Tunnel Test, Does not exceed 25 flame spread, 50 smoke developed.
n. DW144, Class B
o. NRTL product approval, (Subpart S of 29 CFR Part 1910, OSHA)
p. ASTM C 423 noise reduction
q. ASTM E 96/E 96M Procedure A for permeability
r. ASTM C 1071 for erosion
s. ASTM C 518: 2004, Standard Test Method for Steady–State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
t. UL 723, Test for Surface Burning Characteristics of Building Materials
u. NFPA Compliance:

1) NFPA 90A, "Installation of Air Conditioning and Ventilating Systems"
2) NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems"
3) NFPA 255, “Standard Method of Test of Surface Burning Characteristics of Building Materials

3. Outer shell shall be a UV stable 1000 micron high impact resistant titanium infused vinyl with included testing as following:

a. UL-94 Flammability V-0
b. ASTM D-638 Tensile Strength of 6250 psi
c. ASTM D-790 Flexible Strength of 11,000 psi
d. ASTM D-4226 Drop Impact Resistance
e. ASTM D-4216 Cell Classification

C. Construction:

1. Duct wall panel shall be manufactured of CFC-free closed cell rigid thermoset resin (Kingspan Kooltherm, or equal) thermally bonded on both sides to a factory applied 0.001 inches (25 micron) aluminum foil facing reinforced with a fiberglass scrim.
2. Include UV stable, IR reflective 1000-micron high impact resistant titanium infused vinyl, factory bonded to panel exterior using a full lamination process. Lamination process shall permanently bond the vinyl clad to the outer surfaces of the phenolic foam panel to provide a zero-permeability water tight barrier and to form a structurally insulated panel (SIP) in which to form duct segments.

    a. Processes that do not employ a full lamination process are not acceptable.
    b. Self-applied adhesives such as tapes, caulks or cladding that incorporate pressure sensitive or spray adhesives are not acceptable.

3. Thermal conductivity shall be no greater than 0.13 BTU•in/(hr•ft^2•°F) (0.018W/(m•°C)) at 75°F mean temperature.
4. Density of foam shall not be less than 3.5 lb/ft^3 (56 kg/m^3) with a minimum compressive strength of 28 psi (0.2 MPa).
5. Panel shall have:

    a. Continuous rating of 185°F (70°C) inside ducts or ambient temperature surrounding ducts.
    b. Permeability: 0.00 perms maximum when tested according to ASTM E 96/E 96M, Procedure A.
    c. Antimicrobial Agent: Additive for antimicrobial shall not be used but instead, raw product must pass UL bacteria growth testing.
    d. Noise-Reduction Coefficient: 0.05 minimum when tested according to ASTM C 423, Mounting A.
    e. All interior duct liner shall bear UL label and other markings required by UL 181 on each full sheet of duct panel; UL ratings for internal closure materials.
    f. All insulation materials shall be closed cell with a closed cell content of >90%.
    g. R-value:

        1) 1-3/4 inch (45 mm) Thick Panel: 12 R

6. Closure Materials:

    a. V-Groove Adhesive: Silicone (interior only).
    b. UV stable 1000 micron high impact resistant titanium infused vinyl (exterior).

        1) Factory manufactured seamless corners for zero perms.
        2) Cohesive bonded over-lap at corner seam covers for zero perms.
        3) Water resistant titanium infused welded vinyl seams.
        4) Mold and mildew resistant.

    c. Polymeric Sealing System:

        1) Structural Membrane: Aluminum scrim with woven glass fiber with UV stable vinyl clad applied
        2) Minimum Seam Cover Width: 2-7/8” inches (75 mm)
        3) Sealant: Low VOC.
        4) Color: White (colors, matched by architect optional).
        5) Water resistant.
        6) Mold and mildew resistant.

    d. Duct Connectors:

1) Factory manufactured cohesive bonded strips (low pressure only).
2) Factory manufactured all aluminum grip flange.
3) Factory manufactured galvanized 4-bolt flange.

7. Outdoor Cladding:

   a. Duct segments shall incorporate UV stable 1000 micron high impact resistant titanium infused vinyl which is introduced during the manufacturing process.

8. Flange Coverings:

   a. Flanges are field sealed airtight before flange covers are installed. Flange covering consists of the following:

      1) Foam tape insulation with molded 39 mil covers.
      2) Air gap (heating only application) with molded 39 mil covers.

9. Reinforcement:

   a. Ductwork system shall be designed and built with adequate reinforcement to both; withstand air pressure forces from within the duct from blower pressure and shall be built to handle expected snow load for the location where the system is being installed. Refer to General Notes on 999-S Drawings for applicable loading information. All required reinforcement shall be factory installed.

2.02 Ductwork Support Systems:

A. Provide meeting requirements of duct system Manufacturer, Section 40 05 07, and Section 23 31 13.

B. All support components shall be fabricated of 316 stainless steel.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Contractor shall examine proposed installation location and confirm all required dimension for Manufacturer.

B. Coordinate all work with installation work of other trades.

3.02 SHOP FABRICATION

A. Certification:

1. Ducts shall be detailed and fully factory manufactured at a facility authorized by system Manufacturer. All fabrication labor shall be certified “yellow label” building trade professionals, compliant to SMWIA and SMACNA labor guidelines (work preservation observed).

B. Fabrication:

1. Fabricated joints, seams, transitions, reinforcement, elbows, branch connections, access doors and panels, and damage repairs according to manufacturer’s written and detailed instructions.
2. Fabricated 90-degree mitered elbows to include turning vanes.

3. Fabricated duct segments in accordance with manufacturer's written details.
4. Duct Fittings shall include 6 inches of connecting material, as measured, from last bend line to the end of the duct. Connections on machine manufactured duct may be 4 inches.
5. Fabricated duct segments utilizing v-groove method of fabrication. Factory welded or cohesively bonded seams will apply to fully manufactured ductwork and fittings. Internal seams will be supplied with an unbroken layer of low VOC silicone or bonding (for paint shop applications). Each duct segment will be factory supplied with either aluminum grip pro-file or pre-insulated duct connectors in accordance with manufacturer's detailed submittal guide. Applied duct reinforcement to protect against side deformation from both positive and negative pressure per manufacturer's design guide based on specified ductwork size and system pressure.
6. Designed and fabricated duct segments and fittings will be in accordance with "SMACNA Duct Construction Standards" latest edition.
7. Both positive and negative ductwork and fittings shall be constructed to incorporate a UL Listed as a Class 1 air duct to Standard for Safety UL 181 liner with an exterior clad for permanent protection against water intrusion.
8. Duct shall be constructed to exceed requirements for snow and wind loads.

3.03 DUCT INSTALLATION

A. Duct segments shall be installed by Contractor with licensed HVAC installers.

B. Install ducts and fittings to comply with Manufacturer's installation instructions as follows:

1. Install ducts with fewest possible joints.
2. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
3. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
4. Protect duct interiors from the moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."
5. Use prescribed duct support spacing as described in this specification and manufacturer's recommendations.

C. Air Leakage: Duct air leakage rates to be in compliance with "SMACNA HVAC Duct Construction Standards" latest version per applicable leakage class based on pressure.

3.04 HANGERS AND SUPPORT INSTALLATION

A. Contractor to ensure that the ductwork system is properly and adequately supported.

1. Ensure that the chosen method is compatible with the specific ductwork system requirements per Manufacturer's installation detail drawings. Pre-installation should be provided prior to work commencement by installing contractor for approval.
2. 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.

B. Supports on straight runs of ductwork shall be positioned at centers not exceeding 13 feet (3.96 m) for duct sections when fabricated in 13 foot (3.96 m) lengths with duct girth less than 84 inch. Larger duct sizes and short segments with duct girth greater than 84" are to be supported at 8 foot centers or less, in accordance with the Manufacturer's installation details provided prior to work commencement.

C. Ductwork shall be supported at changes of direction, at branch duct connections, tee fittings, parallel under turning vanes and all duct accessories such as dampers, etc.

D. The load of such accessories to the ductwork shall be neutralized by the accessory support.

3.05 FIELD QUALITY CONTROL

A. Inspection: Arrange for Manufacturer's representative to inspect completed installation and provide written report that installation complies with manufacturer's written instructions.

1. Remove and replace duct system where inspection indicates that it does not comply with specified requirements.

B. Perform additional testing and inspecting, at the Contractor's expense, to determine compliance of replaced or additional work with specified requirements.

END OF SECTION

SECTION 23 31 16
THERMOSET FIBERGLASS-REINFORCED PLASTIC DUCTS

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Odorous air fiberglass ductwork and accessories.
2. Fiberglass manual volume dampers.
3. Fiberglass backdraft dampers.
4. Expansion joints/flexible connectors for equipment with FRP ductwork.

1.02 SUBMITTALS

A. Submittal information is identified below:

1. Product Data: Manufacturer's specifications for duct system materials showing dimensions, wall thicknesses, laminate construction, weights, materials of construction, corrosion resistance characteristics, and method of construction.
2. Shop Drawings: Dimensioned layouts of ductwork showing accurately scaled ductwork, including locations of expansion joints.
3. Resin Manufacturer's corrosion charts indicating that selected resin is approved for service defined in this section.
4. After completion of ductwork installation, Manufacturer shall inspect installation and submit a Certificate of Proper Installation.

B. Submit in accordance with Section 01 33 00.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements:

1. PS 15-69: Comply with National Bureau of Standards "Voluntary Product Standard PS 15-69" for construction and fabrication of fiberglass reinforced plastic duct.
2. ASTM C582: Comply with ASTM C582 - Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment.
3. ASTM D3982: Comply with ASTM D3982 - Standard Specification for Contact Molded "Fiberglass" (Glass Fiber Reinforced Thermosetting Resin) Duct and Hoods.
4. SMACNA Thermoset FRP Duct Construction Manual.

B. Contractor shall field verify existing dimensions. Maximum out-of-tolerance shall not exceed ½-inch at connection to existing expansion joint at 70°F. Ductwork having greater tolerance shall be rejected and replaced by this Contractor at no additional cost to Owner.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Protect ductwork, accessories, and purchased products from damage during shipping, storage, and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings.

B. Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade protected from wind.

PART 2 – PRODUCTS

2.01 FRP DUCTWORK

A. Manufacturer:

1. Manufacturer shall have experience in fabricating duct, flanges, fittings, and isometric spools with the filament wound process for greater than 3-years.
2. Fittings, flanges, dampers, and ducts shall be from same manufacturer.
3. Approved Manufacturers:

    a. Perry Fiberglass Products, Inc.
    b. ECS Environmental Solutions.
    c. Belco.
    d. Ershings.
    e. Or Equal.

B. Design Conditions:

1. Service:

    a. Odorous air collection, 100-ppm H2S maximum, 750-ppm NH3 maximum, 100-ppb mercaptans maximum, 100-ppb organic sulphides maximum, in an air stream saturated with water vapor.

2. Design System Maximum Pressure: 15-In. W.C.
3. Design System Maximum Vacuum: 15-In. W.C.
4. Ambient Temperature: -20 to 115°F.
5. Wind loading for external ducts see wind rating notes within General Structural Notes on Drawing Number 10-S-01.

C. General:

1. Rectangular, square, and circular-shaped fiberglass FRP ductwork, transition pieces, and plenums shall be provided at locations shown on Drawings. All fittings shall be FRP as appropriate.
2. Ductwork shall be fabricated in accordance with SMACNA's Thermoset FRP Duct Construction Manual.
3. Ductwork located outdoors shall be designed for external wind and snow loads indicated in General Structural Notes on the Drawings, standard detail sheets.
4. To greatest extent possible, complete joining of FRP duct components in shop to minimize number of field joints. Pre-fabrication shall be completed at the factory of manufacturer and not by Contractor or a third party.
5. All ducts shall have an internal corrosion barrier/liner thickness of not less than 100-mil. Internal corrosion liner shall be built with an innermost corrosion barrier of approximately 20-mils reinforced with C-Veil surfacing veil, followed by two layers of chopped strand mat. Corrosion liner shall be followed by a filament wound structural wall laminate.
6. Provide duct tinted light grey.
7. Out of roundness of duct shall be limited to 1% of diameter.

D. Duct Design:

1. All ductwork shall be of filament wound construction.
2. Duct diameters shall meet the requirements of referenced Regulator Requirements.
3. Duct wall thickness shall be dictated by the greater thickness calculated in accordance with the following:

a. Pressure Service:

1) Safety factor of 10.
2) Minimum wall thickness based on limiting strain.
3) Strength contributed by corrosion barrier/liner shall not be included in calculations.
4) Structural wall thickness shall be calculated by using the formula t=(P*D)/(2*E*Z) where: t=filament wound wall thickness in inches, P=design pressure in PSI, D=inside duct diameter in inches, E=filament wound tensile modulus, and Z=maximum allowable strain (0.0015 in/in).

b. Vacuum Service:

1) Safety factor of 5.
2) Minimum wall thickness shall be determined using Roark's formula for elastic bucking for very long tubes with free ends.
3) Strength contributed by corrosion barrier/liner shall not be included in calculations.
4) Collapse pressure shall be determined using a modulus of elasticity for the filament wound structural portion of the duct not to exceed 3,600,000.

E. Resin:

1. High performance premium grade brominated fire-retardant vinyl polyester resin (AOC K022, Hetron 992, Interplastics 8441, Derakane 510, or equal) shall be used throughout the laminate of all ducts.
2. Resin for ducts shall be fire retardant complying with UL 181 requirements for a Class 0 or 1 duct material.
3. After fabrication, all components shall be coated with a UV resistant gel coat.

F. Fittings:

1. All fittings shall be of filament wound or hand lay-up construction with same resins and corrosion barriers as defined for the duct.
2. Structural portions of filament wound walls shall be supplemented with fiberglass unidirectional reinforcement as required.
3. Structural wall thickness shall be no less than that provided for duct of same size and pressure rating.
4. Elbows 24-in and smaller shall be one-piece sweep, smooth radius elbows with a radius of 1.5 times duct diameter. Elbows 30-in and larger may be mitered with minimum of two mitered joints (3-piece) with a radius of 1.5 times duct diameter.

G. Joints:

1. Field joints shall be butt and strap joints in accordance with ASTM D3982.
2. Field welds shall be made with use of manufacture furnished overlay weld kit.
3. Field welds shall made by an installer approved by the FRP manufacturer.
4. Weld kits shall be supplied to provide a final thickness equal to the minimum wall thickness in Figure 5 of ASTM D3982 and minimum total weld width as specified in Table

H. Flanges:

1. Flanges shall be of hand lay-up construction.
2. Flanges shall be constructed of same premium grade vinylester resin as specified for the duct.
3. Flanges shall be perpendicular to axis of duct to within ½˚ and flat to within 1/32-in for 18-in and smaller flanges and to within 1/16-in for 20-in and larger flanges.

4. Duct to duct flanges shall meet the dimensional requirements of NBS PS 15-69 and drilled in accordance with Table 2 of NBS PS 15-69. Manufacture shall coordinate flange requirements with equipment connections and provide ANSI sized and drilled flanges where required. All bolting hardware shall be of 316 stainless steel construction.

I. Ducting Deflection:

1. The FRP duct shall be designed to limit duct sag of horizontal installed round duct to less than 1% of the dia. based on the below identified support spacing.

J. Supports:

1. Duct supports shall be designed to meet the general requirements of Manufacturer's recommendations, SMACNA's Thermoset FRP Duct Construction Manual, and as follows.
2. Spacing:

   a. Vertical ducts shall be supported at the base of the riser and provided with lateral support at the top of the riser.
   b. Horizontal Spacing:

      1) 3-18-in duct: 10-ft maximum.
      2) 20-36-in duct: 15-ft maximum.

   c. Where flexible connectors shown on drawings, or expansion joints recommended by ductwork Manufacturer, supports shall be provided on each side of joint.
   d. Supports shall be provided on each side of a horizontally installed valve and at the point of connection to equipment.

3. All support saddles and duct attachment components shall be of Fiberglass Reinforced Plastic (FRP) and/or non-metallic construction.
4. All threaded rods and miscellaneous support materials (not in direct contact with duct) shall be of Fiberglass Reinforced Plastic (FRP) and/or non-metallic construction.

K. Workmanship:

1. The finished laminate shall be free from visual defects such as foreign inclusions, dry spots, air bubbles, pin holes, pimples, delamination, exposed reinforcement (glass fibers), and runoff as described below. Care shall be taken to fill voids and crevices at joints and fittings:

		Surface Inspected	
	Defect	**Process Side**	**Exposed Side**
a.	Cracks	None	None
b.	Crazing (fine surface cracks)	None	Max dimension ½", max density 5/ft2, min 2-in apart
c.	Blisters	None	Max ¼-in dia x 1/8-in high, max 1/ft2, min. 2-in apart
d.	Wrinkles and solid blisters	Max deviation of 20% wall thickness but not greater than 1/8-in	Max deviation of 20% wall thickness but not greater than 1/8-in
e.	Pits	Max dimensions, 1/8" dia x 1/32" deep, max number of 10/ft2	Max dimensions, 1/8" dia x 1/16" deep, max number of 10/ft2

f.	Surface porosity (pinholes)	None	None
g.	Chips	None	Max dimension of ¼-in and no deeper than 20% of wall thickness, max density 1/ft2
h.	Dry Spot (non-wetted surface)	None	Max dimension 2 in2/ft2
i.	Entrapped air	1/16” max dia. 10/in2 max density, none to depth of 1/32-in	1/8” max dia. 4/in2 max density, none to depth of 1/32-in
j.	Exposed glass	None	None
k.	Burned areas	None	None
l.	Exposure of cut edge	None	None
m.	Scratches	None	Max length 1-in, max depth 0.01-in
n.	Foreign matter	None	1/16-in dia., max density 1/SF

L. Accessories:

1. Bolts, washers, and nuts: Type 316 stainless steel.
2. Gaskets: Gaskets shall be full-faced, EPDM, minimum 1/8 inch thick and 40 – 60 durometer.

2.02 FIBERGLASS MANUAL VOLUME DAMPERS

A. General:

1. Fiberglass round butterfly dampers shall be provided at the locations shown on Drawings. The dampers will be used to isolate and balance malodorous airflows. The malodorous air will consist of air, hydrogen sulfide gas, methane, and various aromatic hydrocarbon vapors.
2. Leakage rate shall not exceed 3 cfm/SF at 10-in w.c..

B. Frame:

1. Fiberglass reinforced plastic with vinyl ester resin.

C. Blade:

1. Fiberglass reinforced plastic with vinyl ester resin; stiffeners as required.
2. 0.25-in. thick.

D. Axle: Continuous fiberglass reinforced plastic rod with stiffeners as required; 6-in. extension beyond frame.

E. Bearing: Molded PTFE.

F. Blade Stop: Fiberglass reinforced plastic bar.

G. Blade and Shaft Seals: Neoprene.

H. Flanges: Flanges shall conform to specifications in ASTM D3982, Table 2.

I. Butterfly Damper (MVD) Construction:

1. Dampers shall be of single blade type complete with channel-type frame, close fitting blade, full length axle, and bearings. Dampers shall be constructed of fiberglass reinforced plastic using a vinyl ester resin and shall have the same inside dimensions as the connecting ducting. Axles shall not be less than ¾-in. in diameter and shall be continuous through damper.
2. Dampers for balancing service shall be equipped with blade stop and shall have a minimum pressure rating of 30- in. water column.
3. Dampers for isolation service shall be equipped with full circumference blade edge seal, angle type blade stop, and shaft seal. Isolation dampers shall have a minimum pressure rating of 30-in. water column and shall have a maximum leakage rate of 5.3 cu. ft per minute per sq. ft of damper area at minimum pressure rating.

J. Operators:

1. All dampers 24-inch in diameter and larger shall be furnished with an epoxy coated worm gear.
2. Hand Operators:

    a. Heavy-duty, having a locking quadrant suitable for positioning the blade at any intermediate position.

K. Accessories:

1. Bolts, washers, and nuts: Type 316 stainless steel.
2. Gaskets: Gaskets shall be full-faced, EPDM, minimum 3/16 inch thick and 40 – 60 durometer.

2.03 FIBERGLASS GRAVITY BACKDRAFT DAMPERS

A. General:

1. Fiberglass round backdraft dampers shall be provided at the locations shown on Drawings. The dampers will be used to isolate interior spaces when exhaust fans are not operational. The air stream will consist of air, hydrogen sulfide gas, methane, and various aromatic hydrocarbon vapors.
2. Suitable for installation in horizontal and vertical airflow directions.

B. Frame:

1. Fiberglass reinforced plastic with vinyl ester resin.

C. Blade:

1. Fiberglass reinforced plastic with vinyl ester resin.
2. Blade seals for low leakage.

D. Axle: 316 stainless steel.

E. Bearing: Molded PTFE.

F. Flanges: Flanges shall conform to specifications in ASTM D3982, Table 2.

G. Counter weight assembly:

    a. 316 stainless steel arm with 316 stainless steel weight.

2.04 EXPANSION JOINTS/FLEXIBLE CONNECTIONS

A. Manufacturers:

1. Holz Rubber Company, Inc., Style 942.
2. Red Valve Co., Inc.
3. Mercer Rubber Co.
4. Or Equal.

B. General:

1. Expansion joints/flexible connections shall be furnished and installed at the locations indicated on the Drawings and as recommended by FRP ductwork system supplier as required for proper duct installation to account for all thermal expansion of duct system from -10°F to 110°F. At minimum, expansion joints/flexible connectors shall be provided at the inlet and outlet of each fan served, at connection to equipment with moving parts, and at every point where the ductwork changes vertical or horizontal direction and continues for at least 20 feet. Expansion joints/flexible connections shall be of EPDM construction resistant to ultraviolet light and shall be suitable for malodorous air containing air, hydrogen sulfide gas, methane, and various aromatic hydrocarbon vapors.

C. Construction:

1. Expansion joints/flexible connections shall be of EPDM construction. Connections shall be flanged type, compatible with duct flanges specified above and equipment duct flanges, suitable for minimum pressure and vacuum load of 20-in. water column.
2. Where specifically indicated on the Drawings, provide slip-on type flexible connectors. Slip-on type shall be sized to fit tightly on the outside circumference of the duct and shall be secured in place by adjustable stainless steel band type clamps.
3. All hardware shall be of Type 316 stainless steel construction.

PART 3 – INSTALLATION

3.01 INSPECTION

A. General: Examine areas and conditions under which FRP ductwork, dampers, and expansion joints/flexible connections are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION

A. General:

1. Assemble and install ductwork in accordance with recognized industry practices which will achieve air-tight and noiseless (no objectionable noise) systems, capable of performing each indicated service.
2. Install each run with minimum number of joints.
3. Align ductwork accurately at connections, within 1/8-in. misalignment tolerance and with internal surfaces smooth.
4. Support ducts as dictated by ductwork manufacturer.
5. Support vertical ducts at every floor.

B. Field Fabrication:

1. Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements.

C. Duct Routing:

1. Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible.
2. Located runs as indicated by diagrams, details, and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct useable space or block access for servicing building and its equipment.
3. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
4. Limit clearance to ½-in. where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.
5. Coordinate layout with other piping and lighting layouts.

D. Where ducts pass through interior partitions, exterior walls, floor, or roof, refer to Drawings for detail.

E. Coordinate duct installations with installation of accessories, dampers, equipment, controls, and other work associated with duct system.

F. All ductwork and fittings shall be coated in manufacturers standard Gray colored gel coat.

G. Apply all ductwork coating in accordance with manufacturer's requirements.

H. Slope ductwork as specified on Plans.

3.03 FIELD QUALITY CONTROL

A. Any duct found to be improperly installed shall be removed and replaced with ductwork or fittings meeting these specifications. This shall include the following:

1. Fiberglass pipe smaller than specified.
2. Construction joints no properly sealed.

3.04 CONNECTIONS

A. General: All hardware used for connection and support of FRP components shall be of Type 316 stainless steel construction.

B. Connect ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, equipment containing rotating machinery, and/or where indicated on Drawings.

3.05 ADJUSTING AND CLEANING

A. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances.

B. Temporary Closure:

1. At ends of duct which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

C. Balancing:

1. Refer to Section 23 05 93, not work of this Section. Seal any leaks in ductwork that become apparent in balancing process.

END OF SECTION

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SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Drawings and General Requirements of contract including General and Supplementary Conditions and Division 1-specification sections apply to Work of this Section.

B. Extent of duct accessories work is indicated on drawings and in schedules, and by requirements of this section.

C. Types of duct accessories required for project include the following:

1. Manual Dampers.
2. Gravity Backdraft Dampers (BDD).
3. Turning Vanes.
4. Duct Hardware.
5. Duct Access Doors.
6. Flexible Connections.
7. Fire Dampers.

1.02 QUALITY ASSURANCE

A. SMACNA Compliance - Comply with applicable portions of Sheet Metal and Air Conditioning Contractor's National Association (SMACNA) "Duct Construction Standards - Metal and Flexible"

B. NFPA Compliance - Comply with applicable provisions of ANSI/NFPA 90A "Air Conditioning and Ventilating Systems", pertaining to installation of duct accessories.

1.03 SUBMITTALS

A. General:

1. Submit Product Data in sufficient detail to confirm compliance with requirements of this Section.
2. Documentation demonstrating compliance with Spec. Section 00 30 80 regarding the use of American iron and steel in the products being furnished under this Section.

B. Product Data:

1. Manufacturer's specifications for duct system materials showing thicknesses, weights, materials of construction, corrosion resistance characteristics, and method of construction.

C. Submit in accordance with Section 01 33 00.

D. American Iron and Steel Compliance Certification:

1. This project is being funded by the Clean Water State Revolving Fund that requires that all of the iron and steel products used in the project to be produced in the United States (“American Iron and Steel Requirement”). The Contractor and his/her suppliers shall comply with Section 436 of federal H.R. 3547. These requirements apply to and are

binding to the Manufacturer of the products specified in this Section unless variance or De Minimums documentation has been submitted by the Contractor.

2. The Manufacturer shall provide with the shop drawing submittal one signed and dated Certification Letter (a sample copies of which are provided in the Appendix). The Certification Letter shall demonstrate compliance with Section 436 of federal H.R. 3547.

PART 2 - PRODUCTS

2.01 RECTANGULAR MANUAL BALANCING DAMPERS

A. Provide dampers of single blade type or multi-blade type, constructed in accordance with SMACNA Standards. Dampers greater than 10-in height shall be multi-blade type.

B. Dampers installed in aluminum, stainless steel, or FRP duct systems shall be constructed of 304 stainless steel.

C. ½-in hex axle with molded synthetic bearings.

D. All dampers shall be furnished with locking hand quadrant. Dampers installed on insulated duct systems shall be furnished with extended quadrant.

E. Manufacturer - Subject to compliance with requirements, provide dampers of one of the following:

1. Ruskin model MD35.
2. Or equal.

2.02 GRAVITY BACKDRAFT DAMPERS

A. Parallel blade, counterbalanced, adjustable backdraft damper.

B. Provide in vertical or horizontal configuration as required by installation location.

C. Aluminum frame and blade construction with vinyl blade seals.

D. Units installed in electrical rooms shall be set for 0.05 beginning pressure relief.

E. Less than 20 cfm/ft^2 of leakage with 1 in wc differential pressure for size shown on Drawings.

F. Manufacturer – Subject to compliance with requirements, provide dampers of one of the following:

1. Ruskin model CBD2.
2. Or equal.

2.03 TURNING VANES

A. Provide turning vanes constructed of curved blades supported with bars perpendicular to blades and set into side strips suitable for mounting in ductwork.

B. Turning vanes installed in aluminum and stainless steel ductwork shall be of aluminum construction.

C. Manufacturer - Subject to compliance with requirements, provide turning vanes of one of the following:

1. Cain Mfg Co.
2. Tuttle & Bailey.
3. Or equal.

2.04 DUCT HARDWARE

A. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

B. Manufacturers - Subject to compliance with requirements provide duct hardware of one of the following:

1. Ventfabrics, Inc.
2. Young Regulator Co.
3. Or equal.

2.05 DUCT ACCESS DOORS

A. Construct of same or greater gauge as ductwork served, provide insulated doors for insulated ductwork. Access doors shall be constructed of same material as the duct system served.

B. Provide flush frames for uninsulated ductwork, extended frame for externally insulated duct.

C. Provide one side hinged, other side with 1 handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors.

D. Provide access doors on exhaust systems upstream of all elbows with turning vanes and upstream of electric heating coils.

E. Manufacturers - Subject to compliance with requirements provide duct access doors of one of the following:

1. Ruskin Mfg. Co.
2. Ventfabrics, Inc.
3. Or equal.

2.06 FLEXIBLE CONNECTIONS

A. Provide flexible duct connections wherever ductwork connects to vibration isolated equipment.

B. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make air tight joint.

C. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibrations of connected equipment.

D. Manufacturers - Subject to compliance with requirements provide flexible connections of one of the following:

1. Ventfabrics.
2. Or equal.

2.07 FIRE DAMPERS

A. Manufacturers:

1. Greenheck.
2. Louvers and Dampers, Inc.
3. Ruskin.
4. Or equal.

B. Provide curtain type fire dampers of sizes as shown on Drawings.

C. All fired dampers shall have a 1-1/2 or 3 hr fire rating as indicated on Plans.

D. Constructed casing of 11-ga. 304 stainless steel.

E. Provide with fusible link rated at 160°F to 165°F.

F. Provide damper with positive lock in closed position

G. Integral rectangular to round transitions to accommodate ductwork shape shown on Drawings.

PART 3 - EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which duct accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install duct accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards.

B. Install turning vanes in square or rectangular 90° elbows in supply and exhaust air systems, and elsewhere as indicated.

C. Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter. Install access doors where indicated and at each control damper.

D. Coordinate with other work, including ductwork, as necessary to interface installation of duct accessories properly with other work.

3.03 FIELD QUALITY CONTROL

A. Operate installed duct accessories to demonstrate compliance with requirements.

B. Test for air leakage while system is operating.

C. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.

END OF SECTION

SECTION 23 34 23
HVAC POWER VENTILATORS

PART 1 – GENERAL

1.01 SUMMARY

A. This section identifies power ventilators to be furnished and installed as shown on HVAC drawings and schedules and as specified herein. Power ventilators required for this project include:

1. Centrifugal roof ventilators.
2. Centrifugal inline fans.
3. Centrifual ceiling fans.
4. Electronically commutated motors (ECM)

B. The following is not work of this section, refer to Division 16.

1. Power supply wiring from power source to power connection on ventilators. All components required to make a complete installation shall be provided, including but not limited to starters, disconnects and required electrical devices. Electrical equipment specified to be furnished or factory installed by Manufacturer shall be provided under this Section in accordance with Division 26.

C. Control and interlock wiring between ventilators and field installed devices shall be work of Section 23 09 23, installed in accordance with Division 26. Interlock and control wiring specified as factory installed is work of this Section.

1.02 DEFINITIONS, ABBREVIATIONS AND ACRONYMS

A. Acronyms:

1. CCW: Counterclockwise
2. CW: Clockwise
3. ODP: Open Drip Proof
4. TEFC: Totally Enclosed Fan Cooled

B. Unit Abbreviations:

1. CFM: Cubic Feet per Minute
2. FLA: Full Load Amps
3. RPM: Revolutions per Minute
4. V: Volts

1.03 REFERENCES

A. Standard References:

1. AMCA: Air Movement and Control Association
2. NEMA: National Electrical Manufacturers Association
3. NRCA: National Roofing Contractors Association
4. UL: Underwriters Laboratories Incorporated

1.04 SUBMITTALS

A. General:

1. Submit Product Data in sufficient detail to confirm compliance with requirements of this Section. Submit Product Data and Shop Drawings in one complete submittal package. Partial submittals are unacceptable.

B. Product Data:

1. Catalog cuts and product specifications for ventilators specified.
2. Capacity curve or chart with specified operating point clearly identified.
3. List of furnished accessories and accompanying accessory data including tabulation of accessory pressure drops.

C. Shop Drawings:

1. Installation and assembly drawings and specifically prepared technical data for ventilators.
2. Equipment dimension and weights.
3. Wiring Diagrams: Show power and control connections and distinguish between factory-installed and field-installed wiring.

D. Submit in accordance with Section 01 33 00.

E. Instructional Services Documentation:

1. Submit in accordance with Section 01 61 00.

F. Operation and Maintenance (O&M) Data:

1. Operating instructions and maintenance data for materials and products for inclusion in O&M Manual.
2. Manufacturer's written instructions for periodic tests of ventilators in service.
3. Submit in accordance with Section 01 78 23.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Provide power ventilators from firms regularly engaged in manufacture of power ventilators of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Regulatory Requirements:

1. AMCA Compliance - Provide power ventilators which have been tested and rated in accordance with AMCA standards, and bear AMCA Certified Ratings Seal.
2. UL Compliance - Provide power ventilators which are designed, manufactured, and tested in accordance with UL 705 "Power Ventilators".
3. NEMA Compliance - Provide motors and electrical accessories complying with NEMA standards

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver ventilators to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is made safe from such hazards.

B. Store ventilators in clean, dry location.

1.07 MAINTENANCE

A. Extra Materials:

1. Furnish extra materials matching products installed, as described below, packaged with protective covering for storage, and identified with labels describing contents.

a. Furnish one spare set of belts for all belt driven ventilators.

PART 2 – PRODUCTS

2.01 CENTRIFUGAL ROOF VENTILATORS

A. Manufacturers:

1. Greenheck.
2. Carnes Company.
3. Cook Company.
4. Or equal.

B. General: Provide centrifugal roof ventilators of types, sizes, direct or belt-driven and capacities as shown on drawings or schedules.

C. Type:

1. Upblast: Aluminum upblast fan housing with backward inclined aluminum fan wheel.

D. Construction: Fan and motor housing shall be constructed of material described above, fan hood shall be beaded or internally supported for rigidity. Fans shall be provided with pre-punched square curb cap for mounting to roof curb. Up-blast fans shall be provided with drain for the wind band. Drive assembly shall be isolated from fan plate to reduce vibration and noise transmission. All fasteners shall be of stainless steel construction. Fans scheduled to be of spark resistant construction shall be constructed of non-ferrous materials in accordance with AMCA Type B Spark Resistant Construction.

E. Wheel, Shaft and Drive: Fan wheel shall be backward inclined non-overloading or forward curved as noted above. Fan shaft shall be of stainless steel construction. Bearings shall be heavy-duty pillow block bearings selected for minimum life of 100,000 hours at maximum rated speed of the fan. Drives shall be sized for a minimum of 150% of installed motor horsepower. Sheaves shall be of cast iron construction. Motor sheaves shall be adjustable for system balancing. Fans shall be dynamically and statically balanced and tested before shipment.

F. Electrical: Provide factory-wired, fusible type disconnect switch in accordance with Division 26. Fans designated to be of spark-resistant construction and provided with explosion-proof motors shall be provided with a factory wired disconnect switch suitable for the environment in which it is installed and wired in accordance with Division 26.

G. Motors: Provide TEFC motors for all belt drive fans unless specified to be explosion proof, ODP for direct drive fans. Provide motors of scheduled horsepowers in accordance with Division 26, EC motors and integral VFD motors shall be provided in accordance with applicable paragraphs of this Section.

H. Accessories: Provide fans with the following accessories and as scheduled:

1. Dampers: Provide gravity actuated dampers as scheduled. Gravity actuated dampers shall meet the requirements of Section 23 33 00.

2. Birdscreen: Provide manufacturer's standard aluminum birdscreen.
3. Provide stainless steel fasteners and fan shaft.
4. Provide special coatings as scheduled.
5. Speed Control Dial: For all direct drive ventilators, provide speed control, solid state, capable of controlling fan speed from full speed to approximately half speed. Install near fan for balancing purposes only.
6. Roof Curb: Provide manufacturer's standard roof curb as scheduled and in accordance with this Section.
7. Hinge Kit: Provide manufacturer's standard hinge kit constructed of heavy gauge aluminum hinges and hold open cables.

2.02 CENTRIFUGAL INLINE FANS

A. Manufacturers:

1. Greenheck.
2. Carnes Company.
3. Cook Company.
4. Or equal.

B. Type: Inline centrifugal exhaust ventilator.

C. Construction: Fan housing shall be constructed of aluminum. Fan wheel shall be backward inclined, non-overloading of aluminum construction. Drives shall be sized for a minimum of 150% of driven horsepower.

D. Motors: Provide TEFC motors for all fans unless scheduled to be EC motors. Provide motors of scheduled horsepowers in accordance with Division 26. EC motors and integral VFD motors shall be provided in accordance with applicable paragraphs of this Section.

E. Electrical: Provide factory-wire disconnect switch as scheduled.

F. Accessories: Provide fans with the following accessories:

1. Inlet and discharge collars.
2. Vibration isolation kit for horizontal hanging installation.
3. Provide special coatings as scheduled.
4. Insulated fan housing.
5. Insulated filter housing with 1-inch washable filters.
6. Side discharge, see plans for orientation.

2.03 CENTRIFUGAL CEILING FANS

A. Manufacturers:

1. Greenheck.
2. Carnes Company.
3. Cook Company.
4. Or equal.

B. Type: Ceiling mounted centrifugal exhaust ventilator.

C. Construction: Fan housing shall be constructed of galvanized steel with interior lined with sound absorbing insulation. Fan wheel shall be forward curved aluminum construction. Fans shall be provided with integral backdraft damper.

D. Motors: Provide open drip-proof motors of scheduled horsepowers.

E. Accessories: Provide fans with the following accessories as scheduled:

1. Grille: Provide manufacturer's standard ceiling grille.
2. Speed Control Dial: Provide speed control, solid state, capable of controlling fan speed from full speed to approximately half speed. Install near fan for balancing purposes only.

2.04 ELECTRONICALLY COMMUTATED MOTORS (ECM)

A. Provide EC Motors for individual fans when scheduled.

B. Specifically designed for fan applications.

C. AC induction type motors are not acceptable, including:

1. Shaded Pole
2. Permanent Split Capacitor (PSC)
3. Split Phase
4. Capacitor Start
5. 3 phase induction type motors.

D. Permanently lubricated with heavy-duty ball bearings to match the fan load.

E. Prewired to the scheduled voltage and phase.

F. Internal motor circuitry shall convert AC power supplied to the fan to DC power to operate the motor.

G. Motor shall be speed controllable down to 20% of full speed (80% turndown).

H. Speed shall be controlled by either a potentiometer dial mounted on the motor, provided with an interface for dual speed operation, or by a 0-10 VDC signal as scheduled.

I. Motor shall be a minimum of 85% efficient at all speeds

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which power ventilators are to be installed. Do not proceed with installation until unsatisfactory conditions are corrected.

3.02 GENERAL

A. Install all equipment in accordance with manufacturer's installation instructions, industry standards, local Mechanical Code and as indicated in this section and on the Drawings.

B. Coordinate installation with electrical work for power wiring to each piece of powered equipment.

3.03 INSTALLATION

A. Ventilators:

1. Coordinate installation of power ventilators with work of roofing, walls and ceiling as necessary for proper interfacing.

2. Connect ductwork to roof ventilators as shown and in accordance with manufacturer's installation instructions. Solder bottom joints and up 2-inches of side joints of duct under roof ventilator to retain any moisture entering ventilator.
3. Remove shipping bolts and temporary supports within power ventilators. Adjust dampers for free operation.

3.04 IDENTIFICATION

A. Provide equipment identification for all ventilators in accordance with Section 40 05 97.

3.05 FIELD QUALITY CONTROL

A. Upon completion of installation, start-up and test each power and gravity ventilator to demonstrate capabilities and compliance with requirements.

B. Where possible, field correct malfunctioning units then retest to demonstrate compliance.

C. Replace units which cannot be satisfactorily corrected.

3.06 MANUFACTURERS SERVICES

A. Manufacturer's Field Service:

1. Manufacturer's technician for equipment specified herein shall be present at job site or classroom designated by Owner for minimum workdays indicated, travel time excluded, for assistance during construction, startup, and training of Owner's personnel for operation. Include minimum of:

   a. 1/2 Workday for Installation Services.
   b. 1/2 Workday for Post Startup/Instructional Services.

2. Manufacturer shall direct services to specific system and equipment operation, maintenance, and troubleshooting. See Section 01 61 00.

3.07 ADJUSTMENT AND CLEANING

A. Clean factory-finished surfaces. Repair marred or scratched surfaces with Manufacturer's touch-up paint

END OF SECTION

SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Drawings and General Requirements of contract including General and Supplementary Conditions and Division 1 specification sections apply to Work of this Section.

B. Extent of outlets and inlets work is indicated by drawings and schedules, and by requirements of this Section.

C. Types of outlets and inlets required for project include the following:

1. Air Grilles.

1.02 QUALITY ASSURANCE

A. ASHRAE Standards - Comply with American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE) Standard 70 "Methods Of Testing For Rating The Air Flow Performance Of Outlets and Inlets".

B. ADC Test Code - Comply with Air Diffusion Council (ADC) Equipment Test Code 1062R4 "Certification, Rating and Test Manual".

C. ANSI/NFPA Standards - Comply with National Fire Protection Association (NFPA) Standard 90A "Installation of Air Conditioning and Ventilating Systems".

D. ARI Standard - Comply with Air Conditioning and Refrigeration Institute (ARI) Standard 650 - "Air Outlets and Inlets".

1.03 SUBMITTALS

A. Product Data - Submit manufacturer's data on outlets and inlets including the following:

1. Schedule of outlets and inlets indicating drawing designation, model number, size, and accessories furnished.
2. Data sheet for each type of outlet and inlet, and accessory furnished; indicating construction, finish, and mounting details.
3. Performance data for each type of outlet and inlet furnished, including pressure drop, throw and drop, and noise criteria ratings. Indicate selections on data.

B. Submit in accordance with Section 01 33 00.

C. Maintenance Data - Submit maintenance instructions, including cleaning instructions for finishes, and spare parts lists in accordance with Section 01 78 23. Include this data in maintenance manuals.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver outlets and inlets wrapped in factory-fabricated fiberboard type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.

B. Store outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.01 CEILING AIR DIFFUSERS

A. Manufacturers:

1. Carnes.
2. Metal Aire.
3. Krueger Mfg. Co.
4. Price.
5. Titus.
6. Or equal.

B. Provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated on schedule; constructed of materials and components as indicated on schedule.

C. Provide ceiling air diffusers that have, as minimum, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data. Diffusers shall be of the 4-way throw pattern type, unless noted otherwise.

D. Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems, which will contain each type of ceiling air diffuser.

E. Diffusers scheduled to be laminar flow pattern shall be of aluminum construction with a removable, totally enclosed air distribution baffle box and perforated face plate with egg crate grid on plate rear for even airflow distribution. Face plate shall be provided with safety chains to support plate when disconnected from grille housing.

2.02 AIR GRILLES

A. Manufacturers:

1. Carnes.
2. A-J Manufacturing Company.
3. Titus.
4. Or equal.

B. Construction: Provide grilles constructed of aluminum or stainless steel as scheduled.

C. Performance: Provide grilles that do not exceed scheduled maximum pressure drop and noise criteria ratings at scheduled airflow rate or airflow rate as shown on drawings.

D. Substrate Compatibility: Provide grilles with border styles that are compatible with adjacent substrate and specifically manufactured to fit into construction openings with accurate fit and adequate support. Refer to Drawings and Specifications for types of substrate which will contain each type of grille.

E. Grille Face / Pattern: Provide grilles of the following face / pattern type as scheduled. Blade width and spacing shall be dictated by the model number shown in the schedules.

1. Eggcrate: Provide 1/2”x1/2” eggcrate grille.
2. Single Deflection: Provide grilles with 3/4-inch horizontal sets of blades. Refer to schedules for position of each set of blades.
3. Double Deflection: Provide grilles with 3/4-inch horizontal and vertical sets of blades. Refer to schedules for position of each set of blades.

F. Finish: Provide grilles with anodized, satin polish with clear lacquer, matte, clear or white baked enamel finish as scheduled.

PART 3 - EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which outlets and inlets are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install outlets and inlets in accordance with manufacturer's written instructions.

B. Check location of outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

C. Provide balancing dampers on duct take-off to diffusers, and grilles and registers.

D. Paint ductwork visible behind air outlets and inlets matte black.

END OF SECTION

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SECTION 23 74 19
PACKAGED ROOFTOP UNITS

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Packaged rooftop heating and cooling equipment specifically designed for high outside air percentages.
2. Refer to equipment schedules included on Drawings for specific performance information and accessories.

1.02 DEFINITIONS, ABBREVIATIONS AND ACRONYMS

A. Acronyms:

1. CCW: Counterclockwise
2. CW: Clockwise
3. ODP: Open Drip Proof
4. TEFC: Totally Enclosed Fan Cooled

B. Unit Abbreviations:

1. CFM: Cubic Feet per Minute
2. FLA: Full Load Amps
3. RPM: Revolutions per Minute
4. V: Volts

1.03 REFERENCES

A. Standard References:

1. ACGIH: American Conference of Governmental Industrial Hygienists.
2. AGA: American Gas Association
3. ANSI: American National Standards Institute
4. AMCA: Air Movement and Control Association
5. FM: Factory Mutual Insurance
6. NEMA: National Electrical Manufacturers Association
7. NFPA: National Fire Protection Association
8. NRCA: National Roofing Contractors Association
9. UL: Underwriters Laboratories Incorporated

1.04 SUBMITTALS

A. General:

1. Submit Product Data in sufficient detail to confirm compliance with requirements of this Section. Submit Product Data and Shop Drawings in one complete submittal package. Partial submittals are unacceptable.

B. Product Data:

1. Catalog cuts and product specifications for equipment specified, including at a minimum:

a. Fan performance curves with scheduled operating point identified.
b. Total static pressure (TSP) calculations depicting all internal losses with scheduled external (ESP) losses.
c. Heating performance data.
d. Cooling performance data.
e. Reheat performance data.
f. Filter data.
g. Materials of construction and coatings provided.
h. List of accessories included with supporting product data.

2. Motor product data submitted in accordance with Section 26 05 84.

C. Shop Drawings:

1. Installation and assembly drawings and specifically prepared technical data for equipment.
2. Wiring Diagrams: Show power and control connections and distinguish between factory-installed and field-installed wiring.
3. Equipment dimension, weights and recommended clearance requirements.
4. Method of assembly of components.
5. Written functional description of controls furnished with equipment.

D. Submit in accordance with Section 01 33 00.

E. Operation and Maintenance (O&M) Data:

1. Operating instructions and maintenance data for materials and products for inclusion in O&M Manual.
2. Manufacturer's written instructions for periodic tests of equipment in service.
3. Parts list of equipment.
4. Submit in accordance with Section 01 78 23.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firms experienced in manufacturing equipment of types and capacities indicated that have record of successful in-service performance.

B. Items provided under this section shall be listed or labeled by Underwriters Laboratories Inc. (UL), Intertek Group (ETL) or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

C. Regulatory Requirements:

1. All portions of natural gas systems shall comply with requirements of NFPA 54 – National Fuel Gas Code.
2. All indirect fired heater shall comply with latest version of ANSI Z83.8.

D. Single-Source Responsibility: All equipment assemblies shall be from single manufacturer with responsibility for entire system. Unit shall be representative product built from components that have proven compatibility and reliability and are coordinated to operate as unit as evidenced by records of prototype testing.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment and system components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is made safe from such hazards.

B. Handle units and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged units or components, replace with new.

C. Store equipment in clean, dry location. Protect from weather, dirt, fumes, water, construction debris and physical damage.

D. Comply with Manufacturer's rigging and installation instructions for unloading units, and moving them to final location.

1.07 MAINTENANCE

A. Extra Materials:

1. Furnish extra materials matching products installed, as described below, packaged with protective covering for storage, and identified with labels describing contents.

a. One (1) set of match fan belts for each belt-driven fan.
b. Four (4) sets of filters for each unit requiring filters (2 for construction, 1 for substantial completion and one for final completion).

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Trane

B. Carrier

C. Or Equal

2.02 GENERAL

A. Units shall be fully assembled at the factory. All specified components and internal accessories factory installed are tested and prepared for single-point electrical connection.

2.03 ROOFTOP HEATING AND COOLING UNITS, 1 TO 7.5 TONS CAPACITY (RTU100, RTU-121)

A. General:

1. Packaged rooftop units cooling, heating capacities, and efficiencies are AHRI Certified within scope of AHRI Standard 340-360, ANSIZ21.47 and 10 CFR Part 431 pertaining to Commercial Warm Air Furnaces (all gas heating units).
2. Convertible airflow with field selectable horizontal or vertical down ductwork connections.
3. Factory assembled, internally wired, fully charged with R-410A, and 100 percent run tested to check cooling operation, fan and blower rotation, and control sequence before leaving the factory.
4. Colored and numbered wring internal to the unit for simplified identification.
5. Units NRTL listed and labeled.

B. Casing:

1. Zinc coated, heavy gauge, galvanized steel.
2. Weather-resistant baked enamel finish on phosphatized exterior surfaces meeting ASTM B117, 672 hour salt spray test.
3. Hinged Access Doors:

    a. Sheet metal hinges
    b. Provide on access doors serving filter/evaporator, supply fan/heat, and compressor/control sections.

4. Exposed vertical panels and top covers in the indoor air section insulated with a cleanable foil-faced, fire-retardant permanent, odorless glass fiber material.
5. Base pan shall have no penetrations within the perimeter of the curb other than the raised downflow supply/return openings to provide an added water integrity precaution, if the condensate drain backs up.
6. Unit top shall be one piece construction with ribbed top for extra strength and prevention of water pooling, where seams exist, they shall be outside the indoor air-conditioned section.
7. Base of the unit insulated with 1/8 inch, foil-faced, captured and sealed, closed-cell insulation.
8. Unit base shall include provisions for forklift and/or crane lifting on three sides of unit.

C. Coils:

1. Evaporator:

    a. Internally finned, 5/16 inch copper tubes mechanically bonded to a configured aluminum plate fin evaporator coils.
    b. Leak tested to 600 psig.
    c. Assembled unit leak tested to 465 psig.
    d. Dual-sloped condensate drain pan with through the base condensate drain connection.
    e. Black epoxy pre-coated with thermoset vinyl coating, bonded to aluminum fin stock prior to the fin-stamping process.

2. Microchannel Condenser Coils:

    a. Compact recyclable, all aluminum microchannel coil
    b. Brazed aluminum structure
    c. Flat tubes
    d. CompleteCoat™ coating: Cathodic epoxy type electro-disposition coating formulated for high edge build to plate fin and tube heat exchangers.
    e. Leak tested at the factory

D. Compressors:

1. Variable speed offering a minimum 4:1.
2. Direct-drive, hermetic, scroll type compressor.
3. Permanent magnet type motors.
4. Each variable speed compressor shall be match with a refrigerant cooled VFD providing speed control and additional compressor monitoring and safety functions.
5. Suction gas-cooled motor
6. Provide with internal overloads.
7. Crankcase heater for each compressor.

8. Provide minimum 5 year compressor warranty.

E. Controls:

1. Internal controls shall include all required sensors and components for furnace and refrigerant safety mechanisms and functions. Internal controls shall control all aspects of unit.
2. Provide with economizer Fault Detection and Diagnostics (FDD) control package as required to meet 2018 International Energy Conservation Code requirements, including:

   a. Supply air, return air, and outside air temperature sensors.
   b. Damper position monitoring.
   c. Fault indication for any temperature sensor failure, not economizing when should be, economizing when should not be, damper not modulating, and excessive outside air.

3. Provide with BACnet interface for remote control of unit through BAS system specified in Section 23 09 23. Coordinate interface with work of that Section. Interface shall include:

   a. From BAS to RTU:

      1) System run

   b. From RTU to BAS:

      1) Fan speed feedback.
      2) Outside air damper position
      3) Outside air temperature
      4) Return air temperature
      5) Supply air temperature
      6) Space temperature setpoint
      7) Return air humidity setpoint (RTU-121 only)
      8) Return air relative humidity (RTU-121 only)
      9) Percentage cooling capacity
      10) Heating energized
      11) Dirty filter
      12) Each of five FDD fault status

4. Provide fire alarm contact to cause shutdown of unit, closure of outside air damper, opening of return air damper and stoppage of fan when smoke detected by Others. (RTU-121 only)
5. Provide touchscreen human interface, installed in unit control compartment.
6. Factory-wired with necessary controls and contactor pressure lugs or terminal block for power wiring.
7. Provide shipped loose return air humidity sensor and internal controls for enhanced dehumidification (RTU-121 only).
8. Provide space temperature sensor with touchscreen interface, setpoint control, fault indication, and automatic heating/cooling changeover.
9. Provide dirty filter differential pressure switch.
10. Unit shall be configured for through the base electrical and control wiring and provide with an integral disconnect switch.
11. Anti-short cycle timing and time delay between compressors.

F. Filters:

1. 2-inch MERV 8 throwaway filters.

G. Gas Heating Section:

1. Drum and tube stainless steel heat exchanger, stainless steel burners.
2. Corrosion resistant steel induced draft combustion blower.
3. Direct spark ignition.
4. Preprogrammed pre-purge and ignition cycle with burner lock-out and manual reset upon three consecutive failures to ignite.
5. Units shall be suitable for use with natural gas delivered between 7 and 14 inches of water column pressure.
6. Provide minimum 10 year heat exchanger warranty.
7. Provide unit with Through-the-Base gas piping connection.

H. Blower:

1. Variable speed, direct drive plenum fan design.
2. Backward-curved fan wheel with an external rotor direct drive variable speed indoor motor.
3. Variable speed adjustment potentiometer located in the control box.
4. Motors shall be thermally protected.
5. Variable speed direct drive motors.
6. Indoor fan motors meet the U.S. Energy Policy Act of 1992 (EPACT).

I. Outdoor Fan:

1. Direct-drive, statically balanced, draw-through in the vertical discharge position.
2. Permanently lubricated, built-in thermal overload protection included.
3. Phase Monitoring Protection.
4. 3-phase power equipped with phase monitoring protection.
5. Internal protections of motors and compressors for phase loss, phase imbalance, and phase reversal indication.

J. Refrigerant Circuits:

1. Thermal expansion valve.
2. Factory-installed service pressure ports, and refrigerant line filter driers.

K. Accessories:

1. Powered Convenience Outlet:

   a. Powered GFCI, 120V/15amp, 2 plug, convenience outlet with service receptacle disconnect powered from the line side of the unit disconnect. (RTU-100 only)

2. Through-the-Base Electrical with Disconnect Switch:

   a. 3-pole, molded case, disconnect switch with provisions for through-the-base electrical connections.
   b. Disconnect switch installed within unit in a water tight enclosure.
   c. Access through a swinging door.
   d. Wiring provided from the switch to the unit high voltage terminal block.
   e. Switch shall be NRTL recognized.

3. Economizer:

   a. Furnish with 100% barometric relief. (RTU-100 only)
   b. Fully modulating 0-100 percent motor and dampers, minimum position setting, preset

linkage, wiring harness with plug, spring return actuator and fixed dry bulb control.
c. Barometric relief shall provide a pressure operated damper that shall be gravity closing.
d. Barometric relief shall prohibit entrance of outside air during the equipment "off" cycle.

4. Roof Curb:

a. Designed to mate with the unit's downflow supply and return
b. Provide support and a water tight installation when installed properly
c. Shall allow field-fabricated rectangular supply/return ductwork to be connected directly to the curb
d. Curb shall be shipped knocked down for field assembly
e. Shall include wood nailer strips.

2.04 ROOFTOP HEATING AND COOLING UNITS, 10 TO 20 TONS CAPACITY (RTU-120)

A. General:

1. Packaged rooftop units cooling, heating capacities, and efficiencies are AHRI Certified within scope of AHRI Standard 340-360, ANSIZ21.47 and 10 CFR Part 431 pertaining to Commercial Warm Air Furnaces (all gas heating units).
2. Convertible airflow with field selectable horizontal or vertical down ductwork connections.
3. Factory assembled, internally wired, fully charged with R-410A, and 100 percent run tested to check cooling operation, fan and blower rotation, and control sequence before leaving the factory.
4. Colored and numbered wring internal to the unit for simplified identification.
5. Units NRTL listed and labeled.

B. Casing:

1. Zinc coated, heavy gauge, galvanized steel.
2. Weather-resistant baked enamel finish on phosphatized exterior surfaces meeting ASTM B117, 672 hour salt spray test.
3. Hinged Access Doors:

a. Sheet metal hinges
b. Provide on access doors serving filter/evaporator, supply fan/heat, and compressor/control sections.

4. Exposed vertical panels and top covers in the indoor air section insulated with a cleanable foil-faced, fire-retardant permanent, odorless glass fiber material.
5. Base pan shall have no penetrations within the perimeter of the curb other than the raised downflow supply/return openings to provide an added water integrity precaution, if the condensate drain backs up.
6. Unit top shall be one piece construction with ribbed top for extra strength and prevention of water pooling, where seams exist, they shall be outside the indoor air-conditioned section.
7. Base of the unit insulated with 1/8 inch, foil-faced, captured and sealed, closed-cell insulation.
8. Unit base shall include provisions for forklift and/or crane lifting on three sides of unit.

C. Coils:

1. Evaporator:

a. Internally finned, 5/16 inch copper tubes mechanically bonded to a configured aluminum plate fin evaporator coils.
b. Leak tested to 600 psig.
c. Assembled unit leak tested to 465 psig.
d. Dual-sloped condensate drain pan with through the base condensate drain connection.
e. Black epoxy pre-coated with thermoset vinyl coating, bonded to aluminum fin stock prior to the fin-stamping process.

2. Microchannel Condenser Coils:

a. Compact recyclable, all aluminum microchannel coil
b. Brazed aluminum structure
c. Flat tubes
d. CompleteCoat™ coating: Cathodic epoxy type electro-disposition coating formulated for high edge build to plate fin and tube heat exchangers.
e. Leak tested at the factory

D. Compressors:

1. Minimum three compressors.
2. Lead compressor shall be variable speed offering a minimum 4:1 turndown of the lead compressor, 12:1 system turndown.
3. Direct-drive, hermetic, scroll type compressors.
4. Permanent magnet type motors.
5. Each variable speed compressor shall be match with a refrigerant cooled VFD providing speed control and additional compressor monitoring and safety functions.
6. Suction gas-cooled motor
7. Provide with internal overloads.
8. Crankcase heater for each compressor.
9. Provide minimum 5 year compressor warranty.

E. Controls:

1. Internal controls shall include all required sensors and components for furnace and refrigerant safety mechanisms and functions.
2. Provide with economizer Fault Detection and Diagnostics (FDD) control package as required to meet 2018 International Energy Conservation Code requirements, including:

a. Supply air, return air, and outside air temperature sensors.
b. Damper position monitoring.
c. Fault indication for any temperature sensor failure, not economizing when should be, economizing when should not be, damper not modulating, and excessive outside air.

3. Provide with BACnet interface for remote control of unit through BAS system specified in Section 23 09 23. Coordinate interface with work of that Section. Interface shall include:

a. From BAS to RTU:

1) Fan run
2) Fan speed command
3) Cooling Mode
4) Heating Mode
5) Discharge air temperature setpoint

b. From RTU to BAS:

1) Fan speed feedback.
2) Outside air damper position
3) Outside air temperature
4) Return air temperature
5) Supply air temperature
6) Percentage cooling capacity
7) Percentage heating capacity
8) Dirty filter
9) Each of five FDD fault status

4. Provide fire alarm contact to cause shutdown of unit, closure of outside air damper, opening of return air damper and stoppage of fan when smoke detected by Others.
5. Provide touchscreen human interface, installed in unit control compartment.
6. Factory-wired with necessary controls and contactor pressure lugs or terminal block for power wiring.
7. Provide dirty filter differential pressure switch.
8. Unit shall be configured for through the base electrical and control wiring and provide with an integral disconnect switch.
9. Anti-short cycle timing and time delay between compressors.

F. Filters:

1. 2-inch MERV 8 throwaway filters.

G. Gas Heating Section:

1. Drum and tube stainless steel heat exchanger, stainless steel burners.
2. Corrosion resistant steel induced draft combustion blower.
3. Direct spark ignition.
4. Preprogrammed pre-purge and ignition cycle with burner lock-out and manual reset upon three consecutive failures to ignite.
5. Burner shall be fully modulating over a 2.5:1 turndown ratio.
6. Units shall be suitable for use with natural gas delivered between 7 and 14 inches of water column pressure.
7. Provide minimum 10 year heat exchanger warranty.
8. Provide unit with Through-the-Base gas piping connection.

H. Blower:

1. Belt driven with adjustable motor sheaves and adjustable idler arm.
2. Variable speed with inverter duty motor with shaft grounding rings.
3. Motors shall be thermally protected.
4. Indoor fan motors meet the U.S. Energy Policy Act of 1992 (EPACT).

I. Outdoor Fan:

1. Direct-drive, statically balanced, draw-through in the vertical discharge position.
2. Permanently lubricated, built-in thermal overload protection included.
3. Phase Monitoring Protection.
4. 3-phase power equipped with phase monitoring protection.
5. Internal protections of motors and compressors for phase loss, phase imbalance, and phase reversal indication.

J. Refrigerant Circuits:

1. Thermal expansion valve.
2. Factory-installed service pressure ports, and refrigerant line filter driers.

K. Accessories:

1. Through-the-Base Electrical with Disconnect Switch:

a. 3-pole, molded case, disconnect switch with provisions for through-the-base electrical connections.
b. Disconnect switch installed within unit in a water tight enclosure.
c. Access through a swinging door.
d. Wiring provided from the switch to the unit high voltage terminal block.
e. Switch shall be NRTL recognized.

2. Economizer:

a. Furnish with low leakage, 100% outside air economizer with exhaust fan relief.
b. Fully modulating 0-100 percent motor and dampers, minimum position setting, preset linkage, wiring harness with plug, spring return actuator and fixed dry bulb control.
c. Variable speed, powered exhaust fan shall monitor return air pressure or economizer damper position with internal controls to automatically energize exhaust fan as required to relief space pressure.

3. Roof Curb:

a. Designed to mate with the unit's downflow supply and return
b. Provide support and a water tight installation when installed properly
c. Shall allow field-fabricated rectangular supply/return ductwork to be connected directly to the curb
d. Curb shall be shipped knocked down for field assembly
e. Shall include wood nailer strips.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION

A. General - Install units in accordance with Manufacturer's installation instructions, in accordance with local mechanical codes and as indicated on Drawings.

B. Install units plumb and level, firmly anchored in locations indicated, and maintain Manufacturer's recommended clearances.

C. Install electrical and control devices furnished by Manufacturer but not specified to be factory-mounted. Furnish copy of Manufacturer's wiring diagram submittal to Electrical Contractor.

D. Verify that electrical wiring installation is in accordance with Manufacturer's submittal. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

E. Ductwork: Connect supply and return ducts to unit with flexible duct connections. Provide transitions to exactly match unit duct connection sizes.

F. Gas Piping - Refer to Section 23 11 23. Connect gas piping to unit gas train with union, shut-off cock, and drip leg.

G. Provide PVC drain piping from cooling coil drain pan connection.

1. Piping shall be provided with a minimum 4-in deep trap:

a. Cooling coil trap shall be made at equipment connection.

2. Routed at a minimum ¼-in/ft slope toward point of discharge:

a. Route cooling coil drain to nearest roof drain or interior hub, trench, or floor drain as indicated on the Drawings.

3.03 GROUNDING

A. Provide positive equipment ground for all units.

3.04 IDENTIFICATION

A. Provide equipment identification marker complete with equipment name and tag number in accordance with Section 40 05 96. Coordinate field location with Engineer.

3.05 START-UP

A. Engage a factory-authorized service representative to perform start-up service.

B. Start-up units per Manufacturer's written start-up instructions

C. Remove and replace malfunctioning components that do not pass tests and inspections and retest as specified above.

3.06 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:

1. Supplier's or manufacturer's representative for equipment specified herein shall be present at jobsite or classroom designated by Owner for man-days indicated, travel time excluded, for assistance during plant construction, plant startup, and training of Owner's personnel for plant operation. Include:

a. 1/2 workday for Instructional Services.
b. 1/2 workday for Post Startup Services. This shall include equipment start-up and installation inspection.
c. 1/2 workday start-up/coordination services. These services shall be coordinated to be onsite at the same time as the FMS Contractor of Section 23 09 23 to review and test controls of systems and equipment.

2. Supplier or Manufacturer shall direct services specific to equipment operation, maintenance, and troubleshooting. See Section 01 61 00.

END OF SECTION

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SECTION 23 75 23
CUSTOM-PACKAGED OUTDOOR HEATING AND VENTILATING MAKE-UP AIR UNITS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Drawings and General Requirements of Contract including General and Supplementary Conditions apply to Work of this Section.

B. Extent of heating units work required by this section is indicated on drawings and schedules, and by requirements of this section.

1. Direct fired makeup air units.

1.02 QUALITY ASSURANCE

A. UL or ETL Compliance - Provide gas fired heating and ventilating units which are designed, manufactured, and tested in accordance with UL or ETL requirements.

B. AGA Compliance - Construct gas-fired heating and ventilating units sections in accordance with AGA safety standards, and provide AGA label.

1.03 SUBMITTALS

A. General:

1. Submit Product Data in sufficient detail to confirm compliance with requirements of this Section. Submit Product Data and Shop Drawings in one complete submittal package. Partial submittals are unacceptable.

B. Product Data:

1. Catalog cuts and product specifications for equipment specified, including at a minimum:

a. Fan performance curves with scheduled operating point identified.
b. Total static pressure (TSP) calculations depicting all internal losses with scheduled external (ESP) losses.
c. Heating performance data.
d. Filter data.
e. Materials of construction and coatings provided.
f. List of accessories included with supporting product data.

2. Motor product data submitted in accordance with Section 26 05 10.

C. Shop Drawings:

1. Installation and assembly drawings and specifically prepared technical data for equipment.
2. Wiring Diagrams: Show power and control connections and distinguish between factory-installed and field-installed wiring.
3. Equipment dimension, weights and recommended clearance requirements.
4. Method of assembly of components.
5. Written functional description of controls furnished with equipment.

D. Submit in accordance with Section 01 33 00.

E. Operation and Maintenance (O&M) Data:

1. Operating instructions and maintenance data for materials and products for inclusion in O&M Manual.
2. Manufacturer's written instructions for periodic tests of equipment in service.
3. Parts list of equipment.
4. Submit in accordance with Section 01 78 23.

1.04 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Handle units and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged units or components; replace with new.

B. Store units and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with Manufacturer's rigging and installation instructions for unloading units, and moving them to final location.

PART 2 - PRODUCTS

2.01 DIRECT FIRED AIR MAKE UP UNITS

A. Manufacturer's:

1. Trane.
2. Greenheck.

B. General:

1. Factory assembled, piped and wired, gas make up air unit.
2. Heating units shall be natural gas-fired approved for both sea level and high altitude areas.
3. Entire package, including damper controls, fan controls, and all other miscellaneous controls and accessories shall be approved by an independent testing authority, and carry the approval label of that authority as a complete operating package.
4. All units must exceed the ASHRAE 90.1 requirement of steady state efficiency at low fire.
5. Operating natural gas pressure at unit(s) manifold shall be 14 inWC.
6. Provide make-up air unit of scheduled heating capacities and airflows.

C. Configuration:

1. Configuration orientation is from unit inlet toward unit discharge. Access and coil connection locations are right/left as viewed in the direction of airflow (air hitting the back of head).
2. MAU-100: 100% outside air intake hood, intake air damper, filter section with 2 inch washable aluminum filters, direct fired blower section, fan section with down discharge. Right hand unit access, controls and gas piping connections. Unit with double wall insulated bottom, configured for installation on concrete roof curb.
3. Units shall be capable of 100% and 50% airflow. Provide burner bypass damper or modulating burner profile plates as required for this operation.

D. Housing Construction:

1. Unit casing shall be of minimum 18-gauge satin coat galvanized sheet metal.
2. All units shall be internally insulated with 1-in. thick 1-½ lb./cu.ft. density, neoprene coated fiberglass thermal insulation and 22-gauge liner. Units that only insulate the heating section are not acceptable.
3. Surfaces shall be cleaned with a degreasing solvent to remove oil and metal oxides and primed with a two part acid based etching primer.
4. Finish coat shall be 2-part epoxy coating to all exposed surfaces inside and out. For outdoor units add UV topcoat to externally exposed metal. All unprotected metal and welds shall be factory coated.
5. All walls, roofs and floors shall be of formed construction, with at least two breaks at each joint. Joints shall be secured by sheet metal screws or pop rivets. Wall and floor joints shall be broken in and roof joints broken out (exposed) for rigidity. All joints shall be caulked with a water resistant sealant.
6. Units shall be provided with access doors to the following components: fans and motors; filters; dampers and operators; access plenums and electrical control panels; burner compartments. Access doors shall be large enough for easy access. Removal of screwed wall panels will not be acceptable.
7. Provide hinged access doors in welded steel frames. Doors shall be fully lined with closed cell bulb gasket and Leverlok handles. Units of sufficient size in which a person may enter shall have handles operable from each side.
8. Whenever possible, hinged access doors to areas of negative pressure shall open out, and to areas of positive pressure shall open in. Where space constrictions require the use of outward opening doors to an area of positive pressure, a clear warning label must be affixed.
9. Casings shall be supported on formed galvanized steel channel or structural channel supports, designed and welded for low deflections. Integral lifting lugs shall be provided for hoisting.
10. Units shall be provided in horizontal configuration unless otherwise noted and shall be provided with discharge orientation as scheduled.
11. Units scheduled to be provided with a roof curb shall be suitable for curb installation.

E. Air Dampers:

1. Provide inlet or discharge air dampers as scheduled.
2. Damper frames shall be u-shaped galvanized metal sections securely screwed or welded to the unit chassis.
3. Dampers shall be coated with same coating system as unit.
4. Pivot rods of ½-in. aluminum, shall turn in nylon or bronze bushings. Rods shall be secured to the blade by means of straps and set screws.
5. Blades shall be 18-gauge galvanized metal with two breaks on each edge and three breaks on centerline for rigidity.
6. Pivot rod shall “nest” in the centerline break.
7. Damper edges shall interlock.
8. Maximum length of damper between supports shall be 42-in.
9. Damper linkage brackets shall be constructed of galvanized metal.
10. Standard construction for all dampers includes blade ends sealed with an adhesive backed foam polyurethane gasketing. Outdoor air dampers shall also include an all-weather PVC seal, fastened with a positive lock grip and pliable overlap edge on entering air side of interlocking edges. Dampers shall be interlocked from the center.
11. Discharge damper shall be ultra-low leakage type with damper actuator located in a separate enclosure located out of the airstream.
12. Two position inlet dampers shall be parallel blade type.

F. Supply Blowers:

1. Centrifugal fans shall be rated in accordance with AMCA Standard Test Code, Bulletin 210. Fan manufacturer shall be a member of AMCA.
2. Unless indicated otherwise in equipment schedules, supply blowers shall be backward inclined or airfoil type.
3. All fans and fan assemblies shall be dynamically balanced during factory test run.
4. Fan shafts shall be solid ground and polished provided with a rust inhibiting coating.
5. Fan assemblies shall be equipped with greaseable pillow block bearings, with extended lube lines supported on a rigid structural steel frame. Wheel bearings shall be designed for at least 100,000 hours average life.
6. Motor mounting shall be adjustable to allow for variations in belt tension.
7. Fan-motor assemblies shall be provided with vibration isolators. Isolators shall be bolted to steel channel welded to unit floor which is welded to the structural frame of the unit. The isolators shall be neoprene-in-shear type of single 9-in. to 15-in. forward curved fans. All other fans shall incorporate vertical spring type isolators with leveling bolts, bridge bearing waffled pads with minimum 1-in. static deflection designed to achieve high isolation efficiency.
8. Fans shall be attached to the discharge panel by a polyvinyl chloride coated polyester woven fabric, with a sealed double locking fabric to metal connection
9. Motor shall be TEFC, inverter duty with shaft grounding rings meeting the requirements of Section 26 05 10.

G. Heating Section

1. Direct fired natural gas.
2. Burner assembly shall be capable of modulating turn down ratio of 20:1.
3. Units scheduled to be operated at differing flow rates shall be provided with a modulating burner damper to ensure proper burner velocities at all operating airflow conditions.
4. The assembly shall be constructed in a draw through arrangement. Outside air is drawn across the burner section at a constant velocity, within the allowable limits of the burner design.
5. Burner manifold shall be of aluminum construction with 400 series stainless steel mixing plates.
6. All burner combustion air openings shall be located in stainless steel burner plates to maintain design combustion air requirements at all inputs.
7. Designed to burn natural gas below the maximum non-contaminating levels required by OSHA and the ACGIH.
8. Service of and access to the burner igniter and flame rod shall be accomplished through an access door or panel.
9. Burner controls to comply with AGA regulations.
10. Burner assembly and piping to include modulating flow ration valve, fail-safe shut off valve(s), main and pilot pressure regulators, manual shut off valves and electric pilot valve. Flame surveillance shall be with a solid state programmed flame relay complete with flame rod.
11. Unit shall be capable of operating as inlet gas pressures of 11-14 inWC
12. Gas train must be designed to comply with ANSI - Z83.4 and FM.
13. The gas train shall be in a cabinet enclosure.
14. Provide units with following accessories:

    a. High gas pressure switch.
    b. Low gas pressure switch.
    c. Flame rod flame sensing device.
    d. All burner safeties.

H. Filters:

1. Comply with NFPA 90A. Filter sections shall be provided with adequately sized access doors to allow easy removal of filters.
2. For units with filter banks up to 72" high, the filter modules shall be designed to slide out of the unit. Side removal 2-in filters shall slide into a formed metal track, sealing against metal spacers at each end of the track.
3. Two inch thick washable aluminum filters.

I. Controls:

1. Control panel and control transformer.
2. NEMA 4X disconnect switch.
3. High ambient lock-out switch to lock out burner controls when outside air temperature exceeds set-point (adjustable from 45°-65°F).
4. Air proving switch.
5. Low fire start.
6. Electronic flame supervision.
7. Main gas automatic safety shut-off valve.
8. High temperature limit control.
9. Low limit/freezestat control wired to stop unit and initiate freezestat alarm signal when discharge air temperature falls below adjustable setpoint of 35°F. Provide 3-minute time delay on alarm circuit.
10. Spark or hot surface ignited pilot.
11. Blower motor starter and overloads.
12. Damper contact that allows fan to energize after damper opens, damper to close after fan stops and on flame failure.
13. Auxiliary contacts for interlocked exhaust fans.
14. Non-recycling auto by-pass low limit that has built-in sensor checking.
15. Control sequences shall be in accordance with Section 23 09 23.
16. Units shall be provided with VFD for two speed control.
17. Specific Controls:

    a. MAU-100:

        1) The following functions shall be capable of being controlled:

            (a) Digital input: Supply fan start/stop.
            (b) Analog input: Supply fan speed.
            (c) Analog Input: Discharge air temperature setpoint.

        2) The following signals shall be capable of being transmitted to the FMS:

            (a) Digital Output: Common alarm.
            (b) Analog Output: Current draw from VFD.

J. Variable Frequency Drive (VFD):

1. Factory installed variable frequency drive for modulation of:

    a. Supply air blower.

2. VFD shall be factory-programmed for unit-specific requirements and shall not require additional field programming to operate. Programed with two speed control.
3. UL Listed.
4. Match scheduled electrical characteristics and sized based on proposed motor nameplate full load amps.
5. EMC emissions shall meet EN 61800-3, Category C2.

6. Shall include internal overcurrent protection, overvoltage protection, undervoltage protection, earth fault protection, input phase supervision, motor phase supervision, overtemperature protection, motor overload protections, motor stall protection, motor underload protection and short circuit protection.
7. Shall be installed with a 3% input line reactor.
8. Shall be capable of sending current draw data via an analog output.

K. Accessories. Provide units with following accessories, when scheduled with equipment:

1. Outdoor air hood: Provide aluminum rain hood with aluminum bird screen and finish matching cabinet and sized to supply 100 percent outside air.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION

A. General - Install units in accordance with manufacturer's installation instructions, in accordance with local mechanical codes and as indicated on Plans. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

B. Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

C. Verify that electrical wiring installation is in accordance with manufacturer's submittal. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

D. Ductwork: Connect supply and return ducts to unit with flexible duct connections. Provide transitions to exactly match unit duct connection sizes.

E. Gas Piping - Refer to Section 23 11 23. Connect gas piping to unit gas train with union, shut-off cock and drip leg.

3.03 GROUNDING

A. Provide positive equipment ground for all units.

3.04 IDENTIFICATION

A. Provide equipment identification marker complete with equipment name and tag number in accordance with Section 40 05 10. Coordinate field location with Engineer.

3.05 START-UP

A. Engage a factory-authorized service representative to perform start-up service.

B. Start-up units per manufacturer's written start-up instructions

C. Remove and replace malfunctioning components that do not pass tests and inspections and retest as specified above.

3.06 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:

1. Supplier's or manufacturer's representative for equipment specified herein shall be present at jobsite or classroom designated by Owner for work-days indicated, travel time excluded, for assistance during plant construction, plant startup, and training of Owner's personnel for plant operation. Include:

   a. 1/2 work-day for Instructional Services.
   b. 1/2 work-day for Startup Services /Coordination Services. This shall include equipment start-up and installation inspection. These services shall be coordinated to be onsite at the same time as the BAS Contractor of Section 23 09 23 to review and test controls of systems and equipment.

2. Supplier or manufacturer shall direct services to system and equipment operation, maintenance, troubleshooting, and equipment and system-related areas other than wastewater treatment process. See Section 01 78 23.
3. In addition to the services specified above, provide manufacturer's services as required to successfully complete systems demonstration as specified in Section 01 79 10.

END OF SECTION

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SECTION 23 81 26
SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 – GENERAL

1.01 SUMMARY

A. This section identifies self-contained air-conditioners and all associated controls and accessories.

B. The following is not work of this section, refer to Division 26.

1. Power supply wiring from power source to power connection on unit. All components required to make a complete installation shall be provided, including but not limited to starters, disconnects and required electrical devices. Electrical equipment specified to be furnished or factory installed by manufacturer shall be provided under this section.

C. Control and interlock wiring between units and field installed devices is work of Section 23 09 33.

1.02 SUBMITTALS

A. Product Data - Submit manufacturer's technical data. Include in submittal, specifications, capacity ratings, dimensions, weights, materials, accessories furnished, and installation instructions.

B. Shop Drawings - Submit assembly-type shop drawings showing unit dimensions, construction details, methods of assembly of components, and field connection details.

C. Controls - Submit manufacturer's technical data for all control devises. Include control wiring diagrams, with sequence of operation, showing all control devices and controlled equipment.

D. Wiring Diagrams - Submit manufacturer's electrical requirements for power supply wiring to equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

E. Maintenance Data - Submit maintenance data and parts list for piece of scheduled equipment, accessory, and control. Include this data and product data in maintenance manual in accordance with requirements of Section 01 78 23

F. Submit in accordance with Section 01 33 00.

1.03 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide packaged air conditioning units from firms regularly engaged in manufacture of same types and sizes of equipment required, whose products have been in satisfactory use in similar service for not less then 3 years.

PART 2 – PRODUCTS

2.01 DUCTED AIR CONDITIONING SYSTEMS

A. Manufacturer:

1. Trane.

2. Carrier.

B. Indoor, Floor Mounted Air Conditioning Unit (ACU-120):

1. General:

a. Indoor, direct-expansion, ceiling suspended, horizontally mounted air conditioning unit. Air conditioner shall be completely factory assembled in including coil, condensate drain pan, fan motor(s), filters and controls in an insulated casing with a field installed electric heater that can be applied in either vertical or horizontal configuration.
b. Units shall be rated and tested in accordance with ARI standard 210/240, 340/360.
c. Units shall be UL listed and labeled in accordance with UL 465/1995 for indoor blower coil units.

2. Casing:

a. Unit casing shall be constructed of zinc coated, heavy gauge, galvanized steel.
b. Exterior surfaces shall be cleaned, phosphatized and finished with a weather-resistant baked enamel finish.
c. Casing shall be completely insulated with cleanable, foil faced, fire-retardant, permanent, odorless glass fiber material. All insulation edges shall be either captured or sealed.
d. Knockouts shall be provided for unit electrical power and refrigerant piping connections.
e. Access panels be attached by captive screws.
f. Integral return section.
g. Horizontal discharge.

3. Fans:

a. Double inlet, double width, forward curved, centrifugal-type fan(s) with adjustable belt drive shall be standard.
b. Thermal overload protection shall be standard on motor.
c. Fan and motor bearings shall be permanently lubricated.
d. All indoor fan motors shall meet the requirements of the Illinois Energy Conservation Code.

4. Refrigerant System:

a. Dual circuited for minimum two stages of cooling.
b. Include thermostatic expansion valves.

5. Coils:

a. Configured aluminum fin surface shall be mechanically bonded to 3/8" internally enhanced copper tubing and factory pressure and leak tested at 375 psig.
b. Coil is arranged for drawthrough airflow and shall provide a double sloped condensate drain pan constructed of PVC plastic.
c. The drain pan shall be removable for cleaning. The condensate drain pan can be installed in any of four positions allowing for vertical or horizontal application and providing external connections on either side of the unit

6. Electric Heater:
a. Provide with heating capacity as scheduled.
b. Heavy duty nickel chromium heating elements.
c. NRTL listed.
d. Configured to mount directly to ACU discharge air connection and be wired to unit power supply for single point electrical connection.

7. Motors:

    a. Motors shall be permanently lubricated ball bearing with inherent overload protection.
    b. VFD rated motor.

8. Controls:

    a. All necessary controls shall be factory-installed and wired.
    b. Integral variable frequency drive, low voltage terminal strip, and single point power entry shall be included.
    c. Configured for two-speed operation via VFD with adjustments through keypad interface.
    d. BACnet communication interfaced.

9. Filters:

    a. Unit shall have a filter rack with two inch throw-away filters.

10. Electrical Requirements:

    a. Unit shall operate on 460V, three phase, 60 Hz power supply as indicated on the equipment schedule.
    b. Power and control connections shall have terminal block connections.

11. Accessories:

    a. Mounting subbase for vertical installation.
    b. Vibration isolators.

C. Outdoor Air Cooled Condensing Unit (ACCU-120):

1. General:

    a. Units shall be assembled on steel mounting/lifting rails and shall be weather proofed.
    b. Units shall include hermetic scroll compressors, microchannel condenser coils, fans and motors, controls and holding charge of nitrogen.
    c. Operating range shall be between 50°F to 115°F in cooling mode.
    d. Units shall be UL 1995 listed, certified and rated in accordance with ARI Standard 340/ 360 or 365.

2. Unit Cabinet:

    a. Unit casing shall be constructed of zinc coated heavy gauge, galvanized steel.
    b. Exterior surfaces shall be cleaned, phosphatized and finished with a weather-resistant baked enamel finish meeting ASTM B117, 672 hours salt spray test.
    c. Units shall have removable panels with lifting handles allowing access to all major components and controls.

3. Fans:

    a. Direct-drive, statically and dynamically balanced.
    b. Aluminum blades and electro-coated steel hubs shall be used in draw-through vertical discharge position.
    c. Either permanently lubricated totally enclosed or open construction motors shall be provided and shall have built in current and thermal overload protection.
    d. Motor(s) shall have be either ball or sleeve bearing type.

4. Refrigeration System:

    a. Units shall have a two refrigeration circuits with individual compressors. Each refrigeration circuit has an integral subcooling circuit.
    b. A refrigeration filter drier shall be provided.
    c. Unit shall have both a liquid line and suction gas line service valve with gauge port.
    d. Unit shall have two hermetic scroll compressors.
    e. Motor shall be suction gas cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage.
    f. Crankcase heater, discharge line thermostat, internal temperature and current-sensitive motor overloads shall be included for maximum protection.
    g. Scroll type compressors shall provide inherently low vibration and noise by having no suction and discharge valves.
    h. External high and low pressure cutout devices shall be provided.
    i. Evaporator defrost control provided in indoor blower coil shall prevent compressor slugging by temporarily interrupting compressor operation when low evaporator coil temperatures are encountered.

5. Outdoor Coil:

    a. Microchannel style with cathodic, epoxy type, electro-disposition coating.
    b. Factory pressure and leak tested to 660 psig air pressure.

6. Controls and Safeties:

    a. Condensing units shall be completely factory wired with necessary controls and contactor pressure lugs or terminal block for power wiring.
    b. Unit shall provide an external location for mounting a fused disconnect device (furnished by Division 26).
    c. Microprocessor controls.

        1) The microprocessor controls shall provide for all 24-volt control functions. The resident control algorithms shall make all heating, cooling and/or ventilating decisions in response to electronic signals from sensors measuring indoor and outdoor temperatures.
        2) The control algorithm maintains accurate temperature control, minimizes drift from set point, and provides better building comfort.
        3) A centralized microprocessor shall provide anti-short cycle timing and time delay between compressors to provide a higher level of machine protection.
        4) Time delay timers shall be provided to help prevent compressors in dual compressor units from simultaneous start-up. An anti-short cycle timers shall be provided.

    d. BACnet interface:

        1) System shall be capable of maintaining space temperature by control of cooling systems, electric heater, and two speed fan control.
        2) Capable of receiving the following minimum interface points from BAS over BACnet interface:

            (a) Space temperature cooling setpoint.
            (b) Space temperature heating setpoint.
            (c) Unit Run command.
            (d) Call for high speed operation.
            (e) Mechanical Cooling lock-out.
            (f) Electric Heating lock-out.

3) Capable of sending the following minimum interface points to BAS over BACnet interface:

(a) Unit running.
(b) Fan speed (Hi/Lo).
(c) Stage 1 cooling enabled.
(d) Stage 2 cooling enabled.
(e) Heating enabled.
(f) Discharge air temperature.
(g) Filter status.
(h) Common alarm.

4) Refer to Section 23 09 23 for additional control descriptions.

7. Electrical Requirements:

a. Provide units matching scheduled electrical characteristics and 60-Hz operating frequency.
b. Unit electrical power shall be a single point connection.
c. All power and control wiring must be installed per NEC and all local building codes.

8. Accessories:

a. Coated Condenser Coil: A factory applied thermoset vinyl coating, bonded to normal aluminum fin stock. The uniform thickness of the bonded vinyl layer exhibits excellent corrosion protection in salt spray tests performed in accordance with ASTM B177.
b. Anti-Short Cycle Timer: Shall prevent rapid on-off compressor cycling in light load conditions by not allowing compressor to operate for 5-7 minutes upon shutdown. Shall consist of a solid state timing device, 24-volt, 60 cycle with either 5 or 7 minute fixed-off timing period.
c. Supply fan modulation control package, ReliaTel or Equal.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which equipment is to be installed. Do not proceed with installation until unsatisfactory conditions are corrected.

3.02 GENERAL

A. Install all equipment in accordance with manufacturer's installation instructions, industry standards, local Mechanical Code, and as indicated in this section and on the Drawings. Maintain manufacturer's recommended clearances. Install units plumb and level, firmly anchored in locations indicated.

B. Coordinate with equipment Manufacturer any special refrigerant piping requirements for long refrigerant lines, if required based on separation distance of equipment shown on Plans.

C. Route refrigerant lines from outdoor unit to indoor unit. Pipe sizes shall be as recommended by equipment Manufacturer. Refrigerant piping shall be ACR copper piping with brazed fittings or precharged refrigerant tubing kit.

D. Install roof-mounted units on Contractor fabricated roof stand. Anchor unit to stand using inserts or anchor bolts.

E. Coordinate routing of piping and equipment installation locations with other disciplines to avoid conflicts.

F. Provide PVC condensate drain piping routed to nearest floor drain as shown on Drawings.

G. Insulate refrigerant and condensate drain piping in accordance with Section 23 07 00.

H. Coordinate installation with electrical work for power wiring to each piece of powered equipment.

I. Provide control wiring between ACU and ACCU in accordance with manufacturer's recommendation and Section 23 09 23.

3.03 FIELD QUALITY CONTROL

A. Upon completion of installation, start-up and test each piece of powered equipment and control devices to demonstrate capabilities and compliance with requirements.

B. Where possible, field correct malfunctioning units then retest to demonstrate compliance.

END OF SECTION

SECTION 23 82 40
ELECTRIC HEATING TERMINALS

PART 1 – GENERAL

1.01 SUMMARY

A. This section identifies electric heating terminals and all associated controls and accessories to be furnished and installed as shown on HVAC drawings and schedules and as specified herein. Electric heating terminals required for this project include:

1. Washdown Corrosion Resistant Electric Unit Heaters.

B. The following is not work of this section, refer to Division 26.

1. Power supply wiring from power source to power connection on electric heaters. All components required to make a complete installation shall be provided, including but not limited to starters and required electrical devices. Electrical equipment specified to be furnished or factory installed by manufacturer shall be provided under this section.

C. Control and interlock wiring between electric heaters and field installed devices is work of this section. All wiring shall be installed in accordance with Division 26.

1.02 SUBMITTALS

A. Product Data - Submit manufacturer's technical data for electric heating terminals. Include in submittal, specifications, capacity ratings, dimensions, weights, materials, accessories furnished, and installation instructions.

B. Shop Drawings - Submit assembly-type shop drawings showing unit dimensions, construction details, methods of assembly of components, and field connection details.

C. Controls - Submit manufacturers technical data for all factory wired control devises

D. Wiring Diagrams - Submit manufacturer's electrical requirements for power supply wiring to equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

E. Maintenance Data - Submit maintenance data and parts list for piece of scheduled equipment, accessory, and control. Include this data and product data in maintenance manual in accordance with requirements of Section 01 78 23.

F. Submit in accordance with Section 01 33 00.

1.03 QUALITY ASSURANCE

A. Manufacturer's Qualifications: electric heating terminals from firms regularly engaged in manufacture of same types and sizes of equipment required, whose products have been in satisfactory use in similar service for not less then 3 years.

B. Regulatory Requirements:

1. NFPA Compliance - Comply with applicable requirements of NFPA pertaining to installation of space heating equipment. Comply with applicable requirements of NFPA 90A pertaining to installation of ac systems.
2. UL Compliance - Provide electric heating terminals which are designed, manufactured, and tested in accordance with UL 1042. Provide heating terminals that are UL listed and labeled.

PART 2 – PRODUCTS

2.01 WASHDOWN CORROSION RESISTANT ELECTRIC UNIT HEATERS

A. Manufacturers:

1. Qmark, Model QWD.
2. Or equal.

B. Type: Washdown corrosion resistant electric unit heater.

C. Construction: Unit casing shall be constructed heavy 16 gauge 304 stainless steel. Assembled with stainless steel fasteners. Provide with louvered air outlet and inlet grille to act as fan guard.

D. Heating Element: Element shall corrosion resistant 300 stainless steel sheathed with 316 stainless steel fins. Provide units of voltages, phase, and capacities as scheduled.

E. Fans: Fan shall be of aluminum construction with corrosion resistant coating. The fan and motor assembly shall include a totally enclosed permanently lubricated, ball bearing motor, dynamically balanced. Provide with motors in accordance with Division 26.

F. Controls: Provide the following control devices prewired to unit.

1. Power contactor.
2. Fan Delay Relay: Provide fan delay relay to keep unit fan running until all heat is dissipated from the heating elements.
3. Automatic overtemperature cutout.
4. Transformer for 24-volt control circuit.

G. Accessories: Provide unit heaters with the following accessories as scheduled:

1. Factory wired NEMA 4X disconnect switch.
2. Integral NEMA 4X thermostat.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which equipment is to be installed. Do not proceed with installation until unsatisfactory conditions are corrected.

3.02 GENERAL

A. Install all equipment in accordance with manufacturer's installation instructions, industry standards, Illinois Mechanical Code and as indicated in this section and on the Drawings.

B. Coordinate equipment installation locations with other disciplines to avoid conflicts.

C. Coordinate installation with electrical work for power wiring to each piece of powered equipment.

3.03 INSTALLATION

A. Electric Unit Heaters:

1. Install electric unit heaters in accordance with applicable installation requirements of NEC and NECA's "Standard of Installation".
2. Where practical, install unit heaters using manufacturer's standard mounting bracket. Where required, suspend unit heater from substrates by means of threaded rods and building attachments. Adjust hangers so unit is plumb and level. Mount unit heaters at scheduled or noted heights.
3. Touch up scratched or marred enclosure surfaces to match original finishes.
4. Clean dust and debris from unit heaters as installed to ensure cleanliness.

3.04 FIELD QUALITY CONTROL

A. Upon completion of installation, start-up and test each electric heating terminal and control devices to demonstrate capabilities and compliance with requirements.

B. Where possible, field correct malfunctioning units then retest to demonstrate compliance.

END SECTION

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DIVISION 26

ELECTRICAL

SECTION 26 01 26
TESTING ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

A. Description of Work:

1. Prior to energizing equipment, retain services of recognized independent testing laboratory for purpose of performing inspections and tests as herein specified.

2. Ensure electrical equipment supplied by Contractor and Owner is operational within industry and manufacturer's tolerances and installed in accordance with Specifications.

3. Device Ratings and Settings: Verify ratings and settings of overload relays, motor circuit protectors, and overcurrent devices. Make final adjustments of devices in accordance with Section 26 05 73.

B. SUBMITTALS

1. Test Reports:

a. 7 copies of complete testing report utilizing InterNational Electrical Testing Association (NETA) printed forms.
b. Submit report no later than 30 days after testing complete.

2. Submit proof of testing agency qualification.

C. QUALITY ASSURANCE

1. Regulatory Requirements:
a. National Fire Protection Association (NFPA):
b. National Electrical Code (NEC) (NFPA No. 70) and amendments thereto.
c. Underwriters Laboratories, Inc. (UL).
d. American National Standards Institute/International Electrical Testing Association (ANSI/NETA)

2. Inspections and tests shall utilize following.

a. Project Specifications.
b. Project Drawings.
c. Manufacturer's instruction manuals applicable to each particular apparatus.

3. Testing Agency:

a. Meet federal, state, and local safety requirements for accreditation of testing laboratories, CFR Title 29, Part 1907, "Accreditation of Testing Laboratories." Membership in NETA constitutes proof of meeting such criteria.
b. Meet Federal Department of Commerce requirements for nationally independent testing laboratory certification.

4. Permanently record checks and tests and make available to Engineer.

D. PROJECT/SITE CONDITIONS

1. Contractor's Responsibilities:

    a. Supply source of test power to test laboratory at each test site.
    b. Notify testing laboratory when equipment becomes available for acceptance tests.
    c. Coordinate Work to minimize Project delay.
    d. Supply complete set of electrical drawings, specifications, and pertinent change orders to testing laboratory prior to commencement of testing.

2. Testing Laboratory Responsibilities:

    a. Notify Engineer prior to commencement of testing.
    b. Provide material, equipment, labor, and technical supervision to perform such tests and inspections.

3. Recommendations for acceptance or rejection shall be given upon consultation of Engineer, Owner, Contractor, and testing laboratory's representative.

PART 2 – PRODUCTS

(Not Used)

PART 3 – EXECUTION

3.01 GENERAL

A. Test Work and equipment installed to ensure proper and safe operation in accordance with intent of Drawings and Specifications.

1. Check interlocking and automatic control sequences and test operation of safety and protective devices.

B. Correct defects found by Work of this section.

1. Cooperate with Power Company, supplier, and manufacturer representatives in order to achieve proper and intended operation of equipment.

2. Test, adjust, and record operating voltages at each system level before energizing branch circuits.

C. Transformer taps shall be adjusted to obtain as near as possible nominal system voltage.

1. Where transformer is under utility jurisdiction, obtain services of utility to correct voltage.

D. Replace devices and equipment damaged due to failure to comply with this requirement.

E. Balance load among feeder conductors at each panelboard, switchboard or substation and reconnect loads as necessary to obtain reasonable load balance on each phase. Electrical unbalance shall not exceed 20%.

3.02 SWITCHGEAR AND MOTOR CONTROL CENTER ASSEMBLIES

A. Visual and Mechanical Inspections:

1. Inspect for physical damage.

2. Verify equipment supplied and connected in accordance with Specifications.

3. Inspect for proper alignment, anchorage, and grounding.

4. Check tightness of accessible bolted bus joints by calibrated torque wrench method. Refer to manufacturer's instructions for proper foot-pound levels.

5. Key interlock system shall be physically tested to ensure proper function.

6. Doors, panels, and sections shall be inspected for paint, scratches, and fit.

7. Mechanical operation of relays, switches, and other devices.

B. Electrical Tests:

1. Insulation Resistance Test: Measure insulation resistance of each bus section phase-to-phase and phase-to-ground for 1 minute. Test voltage and minimum acceptable values in accordance with Paragraph 3.02.C.2.

2. Test Values:

a. Bolt torque levels shall be in accordance with manufacturer's instructions.
b. Insulation resistance test shall be performed in accordance with following.

Insulation Resistance Test Voltage	
Voltage Rating	**Test Voltage**
150 – 600 volts	1,000 volts
601 – 5,000 volts	2,500 volts
5,001 volts and above	5,000 volts

c. Values of insulation resistance less than rated kilovolts +1 in megohms shall be investigated and corrected.

C. Testing: After installing motor controllers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Sections 7.5, 7.6, and 7.16. Certify compliance with test parameters.
2. Remove and replace malfunctioning units with new units, and retest.

3.03 TRANSFORMERS – DRY-TYPE

A. Testing: Perform field quality-control testing.

1. Test Objectives: To ensure transformer is operational within industry and manufacturer's tolerances, is installed according to Contract Documents, and is suitable for energizing.
2. Report: Submit written report of observations and tests. Report defective materials and installation.
3. Tests: Include following minimum inspections and tests according to manufacturer's written instructions. Comply with IEEE C57.12.91 for test methods and data correction factors.

a. Inspect accessible components for cleanliness, mechanical and electrical integrity, and damage or deterioration. Verify that temporary shipping bracing has been removed. Include internal inspection through access panels and covers.

b. Inspect bolted electrical connections for tightness according to manufacturer's published torque values or, if not available, those specified in UL 486A.
c. Insulation Resistance: Perform megohmmeter tests of primary and secondary winding to winding and winding to ground.

1) Minimum Test Voltage: 1000 Volts, Direct Current (DC).
2) Minimum Insulation Resistance: 500 megohms.
3) Duration of Each Test: 10 minutes.
4) Temperature Correction: Correct results for test temperature deviation from 20 degrees Celsius standard.

4. Test Failures: Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest. Verify that transformers meet specified requirements.

3.04 GROUNDING SYSTEM

A. Testing:

1. Subject completed grounding system to megger test at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells.
2. Measure ground resistance not less than 2 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.
3. Perform tests by 2 point method according to Section 9.03 of IEEE 81.

B. Maximum grounding to resistance values are as follows:

1. Equipment Rated 500 KilovoltAmps (KVA) and Less: 10 ohms.
2. Equipment Rated 500 to 1000 KVA: 5 ohms.
3. Equipment Rated More than 1000 KVA: 3 ohms.
4. Unfenced Substations and Pad-Mounted Equipment: 5 ohms.
5. Manhole Grounds: 10 ohms.
6. Lightning Protection System: 10 ohms.

C. Excessive Ground Resistance: Where resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance and to accomplish recommended work.

D. Report: Prepare certified test reports, of ground resistance at each test location. Include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

END OF SECTION

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Building wires and cables and associated splices, connectors, and terminations for wiring systems rated 600 volts and less.

1.02 DEFINITIONS

A. Underfloor Conduits.

1. Conduits run underground within perimeter of building walls under building floor. This may consist of 1 conduit, or several conduits grouped together.

B. Duct Bank Conduits

1. Conduits run underground outside perimeter of building walls. This may consist of 1 conduit, or several conduits grouped together.

C. Underground Conduits

1. Underground conduits are both underfloor conduits and duct bank conduits.

1.03 QUALITY ASSURANCE

A. Items provided under this Section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code, Article 100.

B. Regulatory Requirements:

1. National Electrical Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver wire and cable according to National Electrical Manufacturers Association (NEMA) WC 26.

PART 2 – PRODUCTS

2.01 BUILDING WIRES AND CABLES

A. UL-listed building wires and cables with conductor material, insulation type, cable construction, and rating as required to meet application and NEC requirements.

B. Wire and cable for 600 volts and below: Soft drawn, copper wire with 600 volt insulation.

1. Conductors:

    a. Annealed, copper in accordance with American Society for Testing and Materials (ASTM) B33.
    b. Stranding: Class B in accordance with ASTM B8.

2. Insulations and Coverings:

    a. Rubber: Conform to NEMA WC 3.
    b. Thermoplastic: Conform to NEMA WC 5.
    c. Cross-Linked Polyethylene: Conform to NEMA WC 7.
    d. Ethylene Propylene Rubber: Conform to NEMA WC 8.

C. Multi-Conductor Shielded VFD Cable in raceways:

1. Use only where specifically called out on drawings.
2. Conductors:

    a. Annealed soft stranded tinned copper.
    b. Class B stranding in accordance with ASTM B3.

3. Insulation:

    a. Flame-retardant Cross-linked Polyethylene (XLPE) insulation – 90 Degree Celsius.
    b. Color-coded per ICEA Method 4; individual conductors colored black with printed number surface printed in contrasting color.

4. Grounding Conductor:

    a. Class B stranded copper per ASTM B8.
    b. Three split symmetrical annealed tinned copper grounding wires in direct contact with shielded sized in accordance with NEC Table 250.122.

5. Dual Shield:

    a. Overall tinned copper braided shield in conjunction with an aluminum/polymer tape shield.

6. Overall Jacket:

    a. Lead-free, flame-retardant, sunlight-resistant Polyvinyl Chloride (PVC), black.

7. Temperature:

    a. Meets cold bending requirements at -25°C
    b. 90°C continuous operating temperature, wet or dry.

8. Flame Test Compliance:

    a. UL 1581/UL 2556 VW-1
    b. UL 1685 Vertical Flame Test
    c. IEEE 383
    d. IEEE 1202
    e. ICEA T-29-520

9. Applications:

    a. For use in raceways.

D. Feeders, service conductors, motor feeders: Single conductor Type XHHW-2.

E. Branch Circuits:

1. Single Conductor Type THHN/THWN (90 degrees Celsius): Above ground and underfloor conduits.
2. Single Conductor Type XHHW-2: Duct bank conduit.
3. No. 12 American Wire Gauge (AWG) minimum size (unless otherwise noted) for branch circuit wiring, including motor circuits.
4. Size 120 volt branch circuits for length of run on following basis.

    a. 0 to 50 feet Run From Panelboard to first outlet: No. 12 AWG minimum.
    b. 51 to 100 feet Run: Increase one wire size, i.e., No. 12 AWG becomes No. 10 AWG.
    c. 101 to 150 feet Run: Increase two wire sizes, i.e., No. 12 AWG becomes No. 8 AWG.
    d. 151 feet and above: Wiring sized for 3% maximum voltage drop.

5. For other branch circuits, voltage drop for branch circuits and feeder circuit combined shall not exceed requirements of the NEC 215.

F. Control Circuits:

1. Single conductor Type THHN/THWN (90 degrees Celsius): Above ground and underfloor conduits.
2. No. 14 AWG minimum size (unless otherwise noted).
3. Multi-wire cable assembly: Duct bank conduits.

G. Non-shielded Instrumentation, Graphic Indication, and Other Control Wiring Operating at Less Than 120 volt: No. 14 AWG except as otherwise indicated with same insulation as control circuits.

1. Single conductor Type THHW/THWN (90 degrees Celsius), above ground and underfloor conduits.
2. Multi-wire cable assembly: Duct bank conduits.

H. Shielded instrumentation wiring, above ground and underfloor conduits:

1. Polyvinyl Chloride (PVC) insulation, tinned copper (19 by 29) stranded, No. 16 AWG, twisted pair or triplet cabled with aluminum mylar shielding, stranded, tinned, No. 18 AWG copper drain wire, and overall black FR-PVC, 90 degrees C, 600 volt jacket.
2. Multi-wire cable assembly: duct bank conduits.

I. Fire Alarm Circuits: In accordance with Section 26 45 00.

J. Multi-Wire Control and Instrumentation Cable Assemblies:

1. Multi-conductor, color-coded cable with number and size of conductors indicated.
2. Where spare conductors are not indicated provide 10% spare conductors. One pair minimum.
3. Control and non-shielded instrumentation.

    a. Bare soft stranded No. 14 or 12 AWG copper in accordance with ASTM B3.
    b. Class B stranded in accordance with ASTM B8.
    c. Type THWN insulation also meeting requirements of NEMA WC-5 with armor-nylon in accordance with UL 83-THHN/THWN (90 degrees Celsius).
    d. Color coded in accordance with NEMA WC-5 Method I Table K-2.
    e. Cabled with suitable fillers.
    f. Overall black FR-PVC, 90 degrees Celsius, 600 volt sunlight resistant jacket.

g. UL listed for installation in cable trays in accordance with NEC Art. 318, Class I, Division 2 hazardous areas and in accordance with NEC 340 and for direct burial.

4. Shielded Instrumentation:

a. Bare soft stranded No. 16 AWG copper in accordance with ASTM B3.
b. Class B stranded tinned copper in accordance with ASTM B8.
c. PVC with nylon armor insulation.
d. Twisted pairs color coded in accordance with NEMA WC-5 Method I Table K-2, and numbered.
e. Individual and overall aluminum mylar shields and seven strand tinned copper drain wires.
f. Overall black FR-PVC 90 degrees C 600 volt sunlight resistant jacket.
g. UL listed for installation in cable trays in accordance with NEC 318, Class I, Division 2 hazardous areas in accordance with NEC 340 and for direct burial.

2.02 CONNECTORS AND SPLICES

A. UL-listed factory-fabricated wiring connectors of size, ampacity rating, material, and type and class for application and for service indicated.

B. Select to comply with Project's installation requirements and as required to meet application.

C. Conductors No. 10 AWG and Smaller: 3M Electric Products, Skotchlok, or equal pre insulated spring connector. Comply with manufacturer's packaging requirements for number, size, and combination of conductors.

D. Conductors No. 8 AWG and Larger: Bronze 2-bolt type connectors with spacer.

2.03 TERMINATIONS

A. Power Conductors: Compression crimp type lugs.

B. Control and Instrumentation Conductors: Compression crimp type fork tongue, insulated support type lugs on terminal strips. Do not splice.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install wires and cables as indicated, according to manufacturer's written instructions and National Electrical Contractors Association (NECA) "Standard of Installation".

B. Remove existing wire from raceway before pulling in new wire and cable.

C. Run wire and cable in conduit unless otherwise indicated on Drawings. Pull conductors into raceway simultaneously where more than 1 is being installed in same raceway.

1. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation.
2. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.
3. Do not draw conductor into conduits until building is enclosed, watertight, and work causing cable damage has been completed.

D. Install cable supports for vertical feeders in accordance with NEC. Provide split wedge type which firmly clamps each individual cable and tightens due to cable weight.

E. For panelboards, cabinets, wireways, switches, and equipment assemblies, neatly form, train, and tie cables in individual circuits.

F. Seal cable and wire entering building from underground between wire and conduit, where cable exits conduit, with non-hardening approved compound.

G. Install wire and cables in separate raceway systems as follows:

1. Exit lights.
2. ac Control.
3. dc control.
4. Shielded instrumentation.
5. Network Cables.
6. Fiber Optic Cables.
7. Fire alarm system.
8. As required by NEC.

H. Where control or instrumentation cables are run in underground conduit and ducts provide multi-wire cable assemblies.

I. Where power cables and instrument/signal cables enter and pass through same distribution box, steel barrier or separate raceways shall continue through box to avoid magnetic interaction between power cables and instrumentation conductors.

J. Do not run instrumentation cables into control cabinets or Motor Control Center (MCC) unless cables are terminated in cabinet or MCC.

K. Wiring at Outlets: Install with at least 12 inch (300 millimeter) of slack conductor at each outlet.

L. Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL 486A.

M. Drawings do not designate number of conductors in conduit nor does location of branch circuits and switch legs indicated on Drawings designate location or routing. Route branch circuits and switch legs as dictated by construction and these Specifications.

3.02 TERMINATIONS AND SPLICES

A. Terminate control, instrumentation, and communication cables on terminal strips in separate terminal cabinets or as shown on Drawings.

B. Power Cable Splices (no splices in cables unless approved by Engineer):

1. Provide continuous lengths of cable without splices in motor circuits and feeders unless otherwise noted. Splices may be installed in motor circuits and feeders with prior approval by Engineer.
2. Install splices and taps that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.
3. Use splice and tap connectors that are compatible with conductor material.
4. Where pre-insulated spring connectors are used for equipment connections, tape connector to wire to prevent loosening under vibration.

5. Each tap, joint or splice in conductors No. 8 AWG and larger shall be taped with two half-lap layers of vinyl plastic electrical tape and finish wrap of color coding tape where required by code.
6. Cable splices shall be made only in manholes, handholes, wireways, distribution boxes, and junction boxes.

C. Power Cable Terminations:

1. Termination of wires with full compression type lugs installed with appropriate hand or hydraulic tool. Use proper dies to achieve the desired compression.
2. For screw type terminal blocks, terminations for stranded conductors shall be made with T & B lock-on fork connector with insulated sleeves.
3. Motor lead conductor terminations shall be made with a T & B or approved equal, full compression lug, full ring type, bolted, and taped as required. For connecting motor lead to service wiring fasten full ring lugs together with cadmium plated steel cap screws, and cover with a minimum of 2 layers 1/2 lap, 3M Scotch No. 33 tape; option: T & B "Motor Stub Splice Insulator".

3.03 CONTROL CIRCUITS

A. Control circuit home runs from same area for the same system returning to same panel, (e.g., Local Controls Panel (LCP), Control Station (CS), etc.) may be combined provided signal and voltage types are not mixed.

B. Following types of home runs shall not be combined with other types:

1. 4-20 milliamp direct current analog; Type 2 shielded cable.
2. 24 volts direct current discrete (e.g., field or LCP powered dry contacts).

3.04 BRANCH CIRCUITS

A. Motor branch circuits and branch circuits for 3 phase circuits shall not be combined.

B. Branch circuits for single phase equipment devices from same Lighting Panel (LP) or Power Panel (PP) may be combined provided that such combining does not result in having to derate ampacity of conductors.

3.05 FEEDERS:

A. Extend feeders at full capacity from origin to termination.

B. Each conduit raceway shall contain only those conductors constituting single feeder circuit.

C. Where multiple raceways are used for single feeder, each raceway shall contain conductor of each phase and neutral if used.

D. Where feeder conductors run in parallel, conductors shall be of same length, material, circular-mil area, insulation type, and terminated in same manner.

E. Where parallel feeder conductors run in separate raceways, raceways shall have same physical characteristics.

F. Confine feeders to insulated portions of building unless otherwise shown.

G. On network systems, neutral shall be run with phase wires. Unbalanced neutral current shall not exceed normal or derated conductor capacity.

3.06 MOTORS AND EQUIPMENT WIRING

A. Provide motor circuits in accordance with diagrams and schedules on Drawings and code requirements, from source of supply to associated motor starter and starter to motor terminal box, including necessary and required intermediate connections.

B. Do not include associated control conductors in same conduit with power conductors.

C. Provide branch circuits to conform with NEC requirements and nameplate ratings. CONTRACTOR responsible for verification of ratings of motors and installing proper branch circuits.

3.07 COLOR CODING

A. Conductors for Lighting and Power Wiring:

Phase	208/120 volts	480/277 volts
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
Travelers	Pink	Purple
Neutral	White	White with non-green stripe
Ground	Green	Green

B. Colored pressure-sensitive plastic tape.

1. Apply in half overlapping turns for minimum of three inches at terminal points, and in junction boxes, pull boxes, troughs, manholes, and handholes.
2. 3/4 inch wide with colors as specified.
3. Apply last two laps of tape with no tension to prevent possible unwinding.
4. Where cable markings are covered by tape, apply tags to cable stating size and insulation type.

C. For modifications and additions to existing wiring systems, color coding shall conform to existing wiring system.

D. Color code for insulated power system wiring shall be in accordance with NEC.

E. Color code for intrinsically safe systems shall be light blue.

3.08 CONTROL, COMMUNICATION AND SIGNAL SYSTEM IDENTIFICATION

A. Install permanent wire marker at termination.

B. Identifying numbers and letters on wire markers shall correspond to those on terminal blocks or wiring diagrams used for installing systems.

C. Plastic sleeve or self adhesive vinyl cloth.

D. Comply with Section 26 05 53.

3.09 FEEDER IDENTIFICATION

A. Manholes, handholes, pullboxes, and junction boxes, install metal tags on circuit cables and wires to clearly designate circuit identification and voltage.

B. Provide tags of embossed brass type, in manholes and handholes showing cable type and voltage rating. Attach tags to cables with slip-free plastic cable lacing units.

C. Comply with Section 26 05 53.

3.10 DIRECT BURIAL

A. Direct bury cables only when indicated on Drawings.

B. Trench and backfill in accordance with Section 31 23 33.

C. Top of cable shall be minimum 24 inch below final grade with 3-inch sand fill above and below cables.

D. Roads and Paving:

1. Where direct burial cable crosses under roads or paving, install cable in galvanized steel conduit sleeves a minimum of 30 inch below surface.
2. If paving is in-place when cable is to be installed, wrought iron pipe or galvanized steel conduit may be driven under paving.
3. Extend conduit or pipe 1 foot beyond each side of paving unless otherwise shown on Drawings.

E. Provide horizontal slack in cables for contraction during cold weather.

F. Install cable in continuous lengths without splices, unless otherwise shown on Drawings.

G. Submersible type connections and terminations designed for cables being installed, when indicated.

H. Install underground line marking tape along and above buried cable in accordance with Section 26 05 53.

1. Bury 1 foot below surface before final backfilling.

3.11 FIELD QUALITY CONTROL

A. Visual and Mechanical Inspection:

1. Inspect cables for physical damage and proper connection in accordance with single-line diagram.
2. Test cable mechanical connections to manufacturer's recommended values using calibrated torque wrench.
3. Check cable color coding with specifications and NEC standards.

B. Electrical Tests:

1. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1000 volts direct current for 1 minute.
2. Perform continuity test to insure proper cable connection.

C. Test Values:

1. Evaluation results by comparison with cables of same length and type. Investigate any value less than 50 megohms.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1– GENERAL

1.01 SUMMARY

A. Section Includes:

1. Grounding of electrical systems and equipment and basic requirements for grounding for protection of life, equipment, circuits, and systems.
2. Grounding requirements specified in this Section may be supplemented in other Sections of these Specifications.

1.02 SUBMITTALS

A. Report of Field Tests and Observations: Certified by Contractor.

B. Test Results:

1. Certified field tests and observation reports indicating and interpreting test reports for compliance with performance requirements.

C. Submit in accordance with Section 01 33 00.

1.03 QUALITY ASSURANCE

A. Comply with Underwriters Laboratories, Inc (UL) 467.

B. Items provided under this section shall be listed or labeled by UL or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

C. Regulatory Requirements:

1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.

PART 2– PRODUCTS

2.01 GROUNDING AND BONDING PRODUCTS

A. Governing Requirements: Where types, sizes, ratings, and quantities indicated are in excess of NEC requirements, more stringent requirements and greater size, rating, and quantity indications govern.

2.02 WIRE AND CABLE GROUNDING CONDUCTORS

A. Conform to NEC Table 8, except as otherwise indicated, for conductor properties, including stranding.

1. Material: Copper.

B. Equipment Grounding Conductors: Insulated with green color insulation.

C. Grounding-Electrode Conductors: Stranded cable.

D. Underground Conductors: Bare, tinned, stranded, except as otherwise indicated.

E. Bare Copper Conductors:

1. Solid Conductors: American Society for Testing and Materials (ASTM) B3.
2. Assembly of Stranded Conductors: ASTM B8.
3. Tinned Conductors: ASTM B33.

2.03 MISCELLANEOUS CONDUCTORS

A. Grounding Bus: Bare, annealed-copper bars of rectangular cross section.

B. Braided Bonding Jumpers: Copper tape, braided No. 3/0 American Wire Gauge (AWG) bare copper wire, terminated with copper ferrules.

C. Bonding Straps: Soft copper, 0.05 inch (1 millimeter) thick and 2 inches (50 millimeters) wide, except as indicated.

2.04 CONNECTOR PRODUCTS

A. Pressure Connectors: High-conductivity-plated units.

B. Bolted Clamps: Heavy-duty type.

C. Exothermic-Welded Connections: Provided in kit form and selected per manufacturer's written instructions for specific types, sizes, and combinations of conductors and connected items.

2.05 GROUNDING ELECTRODES AND TEST WELLS

A. Grounding Rods: Copper-clad steel.

1. Size: 3/4 inch by 120 inches (19 by 3000 millimeters).

B. Plate Electrodes: Copper, square or rectangular shape. Minimum 0.10 inch (3 millimeters) thick, size as indicated.

C. Test Wells: Fabricate from 36 inch (915 millimeters) long, square-cut section of 16 inch (406 millimeters) diameter, Schedule 80, Polyvinyl Chloride (PVC) pipe with end bell as detailed on Drawings.

PART 3 – EXECUTION

3.01 APPLICATION

A. Equipment Grounding Conductors: Comply with NEC Article 250 for types, sizes, and quantities of equipment grounding conductors, except where specific types, larger sizes, or more conductors than required by NEC are indicated.

1. Install equipment grounding conductor with circuit conductors for items below in addition to those required by Code:

a. Feeders and branch circuits.

b. Lighting circuits.
c. Receptacle circuits.
d. Single-phase motor or appliance branch circuits.
e. Three-phase motor or appliance branch circuits.
f. Flexible raceway runs.

2. Nonmetallic Raceways: Install equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.
3. Water Heater, Heat-Tracing, and Antifrost Heater Circuits: Install separate equipment grounding conductor to each electric water heater, heat-tracing assembly, and antifrost heating cable. Bond conductor to heater units, piping, connected equipment, and components.

B. Signal and Communication Systems: For alarm, voice and data, and other communication systems, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding-electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on 1/4 by 2 by 12 inches (6 by 50 by 300 millimeter) grounding bus.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

C. Separately Derived Systems: Where NEC requires grounding, ground according to NEC Paragraph 250-30.

D. Metal Poles Supporting Outdoor Lighting Fixtures: Ground pole to grounding electrode in addition to separate equipment grounding conductor run with supply branch circuit.

E. Common Ground Bonding with Lightning Protection System: Bond electric power system ground directly to lightning protection system grounding conductor at closest point to electric service grounding electrode. Use bonding conductor sized same as system grounding conductor and install in conduit.

F. Piping Systems and Other Equipment: Comply with NEC Article 250 for bonding requirements.

3.02 INSTALLATION

A. Ground electrical systems and equipment according to NEC requirements, except where Drawings or Specifications exceed NEC requirements.

B. Grounding Rods: Locate minimum of 1 rod length from each other and at least same distance from any other grounding electrode.

1. Drive until tops are 2 inches (50 millimeters) below finished floor or final grade, except as otherwise indicated.
2. Interconnect with grounding-electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make these connections without damaging copper coating or exposing steel.

C. Grounding Conductors: Route along shortest and straightest paths possible, except as otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

D. Underground Grounding Conductors: Use bare tinned copper wire. Bury at least 24 inches (600 millimeters) below grade.

E. Metal Water Service Pipe: Provide insulated copper grounding conductors, sized as indicated, 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 by grounding-clamp connectors. Where dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Do not install grounding jumper across dielectric fittings. Bond grounding-conductor conduit to conductor at each end.

F. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding-clamp connectors.

G. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.

H. Test Wells: One for each driven grounding electrode system, except as otherwise indicated. Set top of well flush with finished grade or floor.

I. Concrete-Encased Grounding Electrode (grounding building/structure footing): Fabricate according to NEC Article 250 using minimum of 20 feet (6 meters) of bare tinned copper conductor not smaller than No. 4 AWG or minimum 20 feet (6 meters) rebar 1/2 inch or larger in diameter. Bond grounding conductor to reinforcing steel to at least 4 locations, and to anchor bolts. Extend grounding conductor up in foundation wall.

3.03 CONNECTIONS

A. Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to assure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells. Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Equipment Grounding-Wire Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

D. Noncontact Metal Raceway Terminations: Where metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at both entrances and exits with grounding bushings and bare grounding conductors, except as otherwise indicated.

E. Connections at Test Wells: Use compression-type connectors on conductors and make bolted- and clamped-type connections between conductors and grounding rods.

F. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. Where these requirements are not available, use those specified in UL 486A and UL 486B.

G. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by manufacturer of connectors. Provide embossing die code or other standard method to make visible indication that connector has been adequately compressed on grounding conductor.

H. Moisture Protection: Where insulated grounding conductors are connected to grounding rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.04 FIELD QUALITY CONTROL

A. Test in accordance with Section 26 01 26.

B. Testing Agency: Provide services of qualified independent testing agency to perform specified acceptance testing.

C. Testing: Upon completion of installation of ground-fault protection system and after electrical circuits have been energized, demonstrate capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.

D. Correct malfunctioning units at site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

3.05 RESTORATION

A. Restore disturbed surfaces in accordance with Section 32 92 00.

END OF SECTION

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SECTION 26 05 29
HANGERS AND SUPPORTING FOR ELECTRICAL SYSTEMS

PART 1– GENERAL

1.01 SUMMARY

A. Section Includes:

1. Supports from building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.

1.02 QUALITY ASSURANCE

A. Items provided under this section shall be listed and labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing laboratory (NRTL).

1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

B. Regulatory requirements:

1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.

PART 2– PRODUCTS

2.01 MATERIALS

A. Indoor locations – aluminum or stainless steel.

1. Where GRS conduit is used provide a dissimilar metal separation.

B. Outdoor, corrosive, wet or damp locations – stainless steel.

1. Aluminum supports shall be used for aluminum conduit that is installed along aluminum handrails.

2.02 COATINGS

A. Products for use outdoors.

B. Use Polyvinyl Chloride (PVC) coating where indicated on Drawings.

2.03 MANUFACTURED SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.

B. Fasteners: Types, materials, and construction features as follows:

1. Expansion Anchors: Stainless steel wedge or sleeve type.
2. Toggle Bolts: All stainless steel springhead type.

3. Powder-Driven Threaded Studs: Heat-treated stainless steel, designed specifically for intended service.
4. Nuts, Washers, and Bolts: Stainless steel.

C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers.

E. U-Channel Systems: Channels, with 9/16-inch diameter holes, at minimum of 8 inch on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of same manufacture.

2.04 FABRICATED SUPPORTING DEVICES

A. Shop- or field-fabricate supports or manufacture supports assembled from U-channel components.

B. Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports. Comply with Section 05 50 00.

C. Pipe Sleeves: Provide pipe sleeves of one of following:

1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from following gage metal for sleeve diameter noted:

a. 3 inch and smaller: 20 gauge
b. 4 inch to 6 inch: 16 gauge
c. Over 6 inch: 14 gauge

2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
3. Plastic Pipe: Fabricate from Schedule 80 PVC plastic pipe.

2.05 FIRE RESISTANT JOINT SEALERS

A. Manufacturers:

1. "Dow Corning Fire Stop Foam," Dow Corning Corp.
2. "Pensil 851," General Electric Co.
3. Or equal.

B. Two-part, foamed-in-place, silicone sealant formulated for use in through-penetration fire-stopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.

C. Sealants and accessories shall have fire-resistance ratings indicated, as established by testing identical assemblies in accordance with American Society for Testing and Materials (ASTM) E 814, by Underwriters' Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.

B. Coordinate with structural system and with other electrical installation. Coordinate with light fixtures to ensure hangers and supports are not mounted lower or below light fixtures causing shadows.

C. Raceway Supports: Comply with NEC and following requirements:

1. Conform to manufacturer's recommendations for selection and installation of supports.
2. Strength of each support shall be adequate to carry present and future load multiplied by safety factor of at least four. Where this determination results in safety allowance of less than 200 pounds, provide additional strength until there is minimum of 200 pounds safety allowance in strength of each support.
3. Install individual and multiple (trapeze) 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.
4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1 inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4 inch diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
6. In vertical runs, arrange support so load produced by weight of raceway and enclosed conductors is carried entirely by conduit supports with no weight load on raceway terminals.

D. Vertical Conductor Supports: Install simultaneously with installation of conductors.

E. Miscellaneous Supports: Support miscellaneous electrical components as required to produce same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

F. Sleeves: Install in concrete slabs and walls and other fire-rated floors and walls for raceways and cable installations. For sleeves through fire rated-wall or floor construction, apply UL listed firestopping sealant in gaps between sleeves and enclosed conduits and cables.

G. Conduit Seals: Install seals for conduit penetrations of slabs below grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.

H. Conduit extending through roof shall pass through ceiling box at roof line.

1. Provide 14 gauge minimum copper box complete with watertight soldered seams and flanged to serve as pitch pocket for each conduit.
2. Install conduit and pitch pocket in advance of roofing work.

I. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with following:

1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
2. Holes cut in concrete shall not cut main reinforcing bars. Fill holes that are not used.
3. Load applied to any fastener shall not exceed 25% of proof test load. Use vibration- and shock- resistant fasteners for attachments to concrete slabs.

END OF SECTION

SECTION 26 05 33.13
CABINETS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Outlet and device boxes.
2. Pull and junction boxes.
3. Cabinets.
4. Hinged door enclosures.
5. Boxes and fittings for hazardous locations.

B. Conduit-body-type electrical enclosures and wiring fittings are specified in Section 26 05 33.16.

1.02 DEFINITIONS

A. Cabinets: Enclosure designed either for surface or for flush mounting and having frame, or trim in which door or doors may be mounted.

B. Device Box: Outlet box designed to house receptacle device or wiring box designed to house switch.

C. Enclosure: Box, case, cabinet, or housing for electrical wiring or components.

D. Hinged Door Enclosure: Enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with walls of box.

E. Outlet Box: Wiring enclosure where current is taken from wiring system to supply utilization equipment.

F. Wiring Box: Enclosure designed to provide access to wiring systems or for mounting of indicating devices or of switches for controlling electrical circuits.

1.03 SUBMITTALS

A. Product Data: Submit for cabinets and enclosures with classification higher than National Electrical Manufacturers Association (NEMA) 1.

B. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

B. Regulatory Requirements:

1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA 70).

PART 2 – PRODUCTS

2.01 CABINETS, BOXES, AND FITTINGS, GENERAL

A. Electrical Cabinets, Boxes, and Fittings: Of indicated types, sizes, and NEMA enclosure classes. Where not indicated, provide units of types, sizes, and classes appropriate for use and location. Provide items complete with covers and accessories required for intended use. Provide gaskets for units in damp or wet locations.

2.02 MISCELLANEOUS MATERIALS AND FINISHES

A. Fasteners for General Use: Corrosion resistant screws and hardware including cadmium and zinc plated items.

B. Fasteners for Damp or Wet Locations: Stainless steel screws and hardware.

C. Fittings for Boxes, Cabinets, and Enclosures: Conform to UL 514B. Malleable iron or zinc plated steel for conduit hubs, bushings and box connectors.

D. Finishes:

1. Exterior Finish: Galvanized or Gray baked enamel for items exposed in finished locations except as otherwise indicated.
2. Interior Finish: Where indicated, white baked enamel.

2.03 METAL OUTLET, DEVICE, AND SMALL WIRING BOXES

A. General:

1. Conform to UL 514A and UL 514B.
2. Boxes shall be of type, shape, size, and depth to suit each location and application.

B. Steel Boxes: Conform to NEMA OS 1. Boxes shall be sheet steel with stamped knockouts, threaded screw holes and accessories suitable for each location including mounting brackets and straps, cable clamps, exterior rings and fixture studs.

C. Galvanized Cast-Iron Boxes: Iron alloy, waterproof, with threaded raceway entries and features and accessories suitable for each location, including mounting ears, threaded screw holes for devices and closure plugs.

2.04 PULL AND JUNCTION BOXES

A. General: Comply with UL 50 for boxes over 100 cubic inch volume. Boxes shall have screwed or bolted on covers of material same as box and shall be of size and shape to suit application.

B. Galvanized Steel Boxes: Flat rolled, code gauge, sheet steel with welded seams. Where necessary to provide rigid assembly, construct with internal structural steel bracing. Hot-dip galvanized after fabrication. Cover shall be gasketed.

C. Stainless-Steel Boxes: Fabricate of stainless steel conforming to Type 304 of American Society for Testing and Materials (ASTM) A167. Where necessary to provide rigid assembly, construct with internal structural stainless steel bracing. Cover shall be gasketed.

D. Boxes Approved for Classified Locations: Cast metal or cast nonmetallic boxes conforming to UL 886 listed and labeled for use in specific location classification, and with specific hazardous material encountered. Conduit entrances shall be integral threaded type.

2.05 CABINETS

A. Manufacturers: Hoffman or approved equal.

B. Comply with UL 50.

C. Construction (dry location): Flat rolled, code gauge, galvanized, sheet steel, NEMA 1 class except as otherwise indicated. Cabinet shall consist of box and front consisting of 1 piece frame and hinged door. Arrange door to close against rabbet placed around inside edge of frame, with uniformly close fit between door and frame. Provide concealed fasteners, not over 24 inch apart, to hold fronts to cabinet boxes and provide for adjustment. Provide flush or concealed door hinges not over 24 inch apart and not over 6 inch from top and bottom of door. For flush cabinets, make front approximately 3/4 inch larger in each dimension. For surface mounted cabinets make front same height and width as box.

D. Construction (outside, damp, or wet location): NEMA 4X Stainless Steel.

E. Doors: Double doors for cabinets wider than 24 inch Telephone cabinets wider than 48 inch may have sliding or removable doors.

2.06 STEEL ENCLOSURES WITH HINGED DOORS

A. Manufacturers: Hoffman or approved equal.

B. Comply with UL 50 and NEMA ICS 6.

C. Construction:

1. Sheet steel, 16 gauge, minimum, with continuous welded seams. NEMA class as indicated; arranged for surface mounting.
2. Stainless steel.

D. Doors: Hinged directly to cabinet and removable, with approximately 3/4 inch flange around each edge, shaped to cover edge of box. Provide handle operated, key locking latch. Individual door width shall be no greater than 24 inch. Provide multiple doors where required.

E. Mounting Panel: Provide painted removable internal mounting panel for component installation.

F. Enclosure: NEMA 12 except as indicated. Where door gasketing is required, provide neoprene gasket attached with oil-resistant adhesive, and held in place with steel retaining strips. For enclosures of class higher than NEMA 1, use hubbed raceway entrances.

G. Enclosure: NEMA 4X in outside, damp, or wet locations.

2.07 CAST METAL ENCLOSURES WITH HINGED DOORS

A. Copper free aluminum with bolted, hinged doors. Where used at hazardous (classified) locations, enclosures shall conform to UL and shall be listed and labeled for classification of hazard involved.

2.08 TERMINAL STRIPS

A. Manufacturers:

1. Square D.
2. Buchanan.
3. Or equal.

B. Channel mount snap-on type.

C. Individual gangable with nylon bases.

D. Solderless box lug type rated at 600 volts to accommodate No. 22 to 8 American Wire Gauge (AWG) wire or as otherwise indicated.

E. Provide 50% spare terminals.

PART 3 – EXECUTION

3.01 INSTALLATION, GENERAL

A. Locations: Install items where indicated and where required to suit code requirements and installation conditions.

B. Cap unused knockout holes where blanks have been removed and plug unused conduit hubs.

C. Support and fasten items in accordance with Section 26 05 29.

D. Sizes shall be adequate to meet NEC volume requirements, but in no case smaller than sizes indicated.

E. Remove sharp edges where they may come in contact with wiring or personnel.

3.02 APPLICATIONS

A. Cabinets: Flush mounted, NEMA Type 1 enclosure except as otherwise indicated.

B. Hinged Door Enclosures: Sheet steel, baked enamel finish, NEMA type 12 enclosure except as indicated.

C. Hinged Door Enclosures Outdoors: Galvanized sheet steel with baked enamel finish, NEMA type 12. Install drip hood, factory tailored to individual units.

D. Hinged Door Enclosures in Corrosive Locations: NEMA type 4X 316 stainless steel metal enclosure, or as indicated on Drawings.

E. Outlet Boxes and Fittings: Install outlet and device boxes and associated covers and fittings of materials and NEMA types for each location in conformance with following requirements unless otherwise noted:

1. Interior Dry Locations: Sheet steel, NEMA type 1 for flush mounting and feraloy Type FS or FD cast boxes with threaded conduit hubs for surface mounting.
2. Locations Exposed to Weather or Dampness: 316 Stainless Steel, NEMA type 4X enclosures.
3. Wet Locations: 316 Stainless Steel, NEMA type 4X enclosures.
4. Corrosive Locations: 316 Stainless Steel, NEMA type 4X enclosures.
5. Metal Door Jambs: Narrow partition boxes with internal ears.
6. Hazardous (Classified) Locations: NEMA type listed and labeled for location and class of hazard indicated.

F. Pull and Junction Boxes: Install pull and junction boxes of materials and NEMA types for each location in conformance with following requirements unless otherwise noted:

1. Interior Dry Locations: Sheet steel, NEMA type 1 for flush mounting and feraloy Type FS or FD cast boxes with threaded conduit hubs for surface mounting.
2. Locations Exposed to Weather or Dampness: Galvanized, cast metal, NEMA Type 3R.
3. Wet Locations: 316 Stainless Steel, NEMA type 4X enclosures.
4. Corrosive Locations: 316 Stainless Steel, NEMA type 4X enclosures.
5. Hazardous (Classified) Locations: NEMA type listed and labeled for location and class of hazard indicated.

3.03 INSTALLATION OF OUTLET BOXES

A. Outlets at Windows and Doors: Locate close to window or door trim.

B. Column and Pilaster Locations: Locate outlet boxes for switches and receptacles on columns or pilasters so centers of columns are clear for future installation of partitions.

C. Locations in Special Finish Materials: For outlet boxes for receptacles and switches mounted in desks or furniture cabinets or in glazed tile, concrete block, marble, brick, stone or wood walls, use rectangular shaped boxes with square corners and straight sides. Install boxes without plaster rings. Saw cut recesses for outlet boxes in exposed masonry walls.

D. Gasketed Boxes: At following locations use cast metal, threaded hub type boxes with gasketed weatherproof covers:

1. Exterior locations.
2. Where surface mounted on unfinished walls, columns or pilasters. (Cover gaskets may be omitted in dry locations).
3. Where exposed to moisture laden atmosphere.
4. Where indicated.

E. Mounting: Mount outlet boxes for switches with long axis vertical or as indicated. Mount boxes for receptacles vertically. Gang boxes shall be mounted with long axis horizontal. Locate box covers or device plates so they will not span different types of building finishes either vertically or horizontally. Locate boxes for switches near doors on side opposite hinges and close to door trim, even though electrical floor plans may show them on hinge side.

F. Ceiling Outlets: For fixtures, where wiring is concealed, use outlet boxes 4 inch sq by 1-1/2 inch deep, minimum with raised plaster or tile cover. Provide 3/8 inch fixture stud.

G. Cover Plates for Surface Boxes: Use plates sized to box front without overlap.

H. Protect outlet boxes to prevent entrance of plaster, and debris. Thoroughly clean foreign material from boxes before conductors are installed.

I. Concrete Boxes: Use extra deep boxes to permit side conduit entrance without interfering with reinforcing, but do not use such boxes with over 6 inch depth.

J. Secure boxes rigidly to substrate upon which being mounted or solidly embed boxes in concrete or masonry. Do not support from conduit, mechanical ductwork or piping.

K. Set boxes in concealed conduit runs, flush with wall surfaces, with or without covers as required.

L. Do not install boxes back to back or through wall. Offset outlet boxes on opposite sides of wall minimum 12 inch

M. Set outlet boxes parallel to construction, securely mounted and adjusted to set true and flush with finished surface.

N. Do not burn holes, use knockout punches or saw.

O. Use handy boxes only where specifically indicated.

P. Provide outlet box divider barriers between 277/480 volt and 120/240 volt devices as required per NEC.

Q. Where emergency switches occur adjacent to normal light switches, install in separate boxes in accordance with NEC and device plate color coding separation.

R. Existing Outlet Boxes: Where extension rings are required to be installed, drill new mounting holes in rings to align with mounting holes on existing boxes where existing holes are not aligned.

3.04 OUTLET BOX LOCATIONS

A. Locate flush mounted wall boxes in corner of nearest brick or block to keep cutting to minimum.

B. Location of outlets and equipment as shown on Drawings is approximate and exact location to be verified and shall be determined by:

1. Construction or code requirements.
2. Conflict with equipment or other trades.
3. Equipment manufacturer's drawings.

C. Minor modification in location of outlets and equipment considered incidental up to distance of 10 feet with no additional compensation, provided necessary instructions given prior to roughing in of outlet.

D. Mounting heights for devices and equipment to be measured from finished floor to centerline of device and unless otherwise noted on Drawings as follows.

1. Switches: 48 inch above floor.
2. Alternating Current Receptacles and Telephone Outlets: 15 inch above floor or 6 inch above counters, counter backsplashes, and baseboard radiators in finished areas; 48 inch above floor in unfinished areas.
3. Wall Bracket Lighting Fixtures: 8 inch above mirrors or 6 feet 6 inch above floor.
4. Pushbuttons: 48 inch above floor.
5. Motor Starters and Disconnect Switches: 60 inch above floor
6. Thermostats: 60 inch above floor.
7. Bells and Horns: 8 feet 0 inch above floor.
8. Clocks: 8 feet 0 inch above floor.

3.05 INSTALLATION OF PULL AND JUNCTION BOXES

A. Box Selection: For boxes in main feeder conduit runs, use sizes not smaller than 8 inch sq by 4 inch deep. Do not exceed 6 entering and 6 leaving raceways in single box. Quantities of conductors (including equipment grounding conductors) in pull or junction box shall not exceed following:

Size of Largest Conductors in Box	Maximum No. of Conductors in Box
No. 4/0 AWG	30
250 Kcmil	20
500 Kcmil	15
Over 500 Kcmil	10

1. Cable Supports: Install clamps, grids, or devices to which cables may be secured. Arrange cables so they may be readily identified. Support cable at least every 30 inch inside boxes.
2. Mount pull boxes in inaccessible ceilings with covers flush with finished ceiling.
3. Size: Provide pull and junction boxes for telephone, signal, instrumentation, control, and other systems at least 50% larger than would be required by the NEC for boxes smaller than 24 inch by 24 inch, or as indicated. Locate boxes strategically and provide shapes to permit easy pulling of future wires or cables of types normal for such systems.

3.06 INSTALLATION OF CABINETS AND HINGED DOOR ENCLOSURES

A. Mount with fronts straight and plumb.

B. Install with tops 78 inch above floor.

C. Set cabinets in finished spaces flush with walls.

D. Terminate wires and cables on terminal strips.

3.07 GROUNDING

A. Electrically ground metallic cabinets, boxes, and enclosures. Where wiring to item includes grounding conductor, provide grounding terminal in interior of cabinet, box or enclosure.

3.08 CLEANING AND FINISH REPAIR

A. Upon completion of installation, inspect components. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, abrasions and weld marks.

B. Galvanized Finish: Repair damage using zinc-rich paint recommended by manufacturer.

C. Painted Finish: Repair damage using matching corrosion inhibiting touch-up coating.

END OF SECTION

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SECTION 26 05 33.16
CONDUIT FOR ELECTRICAL SYSTEMS

PART 1– GENERAL

1.01 SUMMARY

A. Section includes:

1. Raceways:

a. Galvanized rigid steel conduit (GRS).
b. Polyvinyl chloride (PVC) externally coated galvanized rigid steel conduit (CGRS).
c. Polyvinyl Chloride externally coated intermediate metal conduit (CIMC).
d. Flexible metal conduit (FMC).
e. Liquidtight flexible metal conduit (LFMC).
f. Hazardous Flexible Metal Conduit.
g. Rigid nonmetallic polyvinyl chloride conduit (PVC).

1.02 DEFINITIONS

A. Underfloor Conduits.

1. Conduits which run underground within perimeter of building walls under building floor. This may consist of one conduit, or several conduits grouped together.

B. Duct Bank Conduits

1. Conduits which run under ground outside perimeter of building walls. This may consist of one conduit, or several conduits grouped together.

C. Underground Conduits

1. Underground conduits are both underfloor conduits and duct bank conduits.

1.03 SUBMITTALS

A. Submittals are not required if Contractor supplies materials or equipment as specified. If Contractor proposes substitutions to material or equipment submittals identified below are required.

1. Product data.
2. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

B. Regulatory Requirements:

1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.

C. Comply with National Electrical Contractors Association (NECA) "Standard of Installation."

PART 2 – PRODUCTS

2.01 METAL CONDUIT

A. Galvanized Rigid Steel Conduit: American National Standards Institute (ANSI) C80.1.

B. Plastic-Coated Steel Conduit and Fittings: National Electrical Manufacturers Association (NEMA) RN 1 and ETL Verified Polyvinyl Chloride-001 Labeled.

C. Flexible Metal Conduit: Zinc-coated steel.

D. Liquidtight Flexible Metal Conduit: Flexible steel conduit with Polyvinyl Chloride jacket.

E. Hazardous Flexible Metal Conduit: Stainless steel braid.

2.02 NONMETALLIC CONDUIT

A. Rigid Nonmetallic Polyvinyl Chloride (PVC) Conduit: NEMA TC 2, PVC Chloride

1. Concrete Encased: Schedule 40.
2. Direct Buried: Schedule 80.

B. PVC Conduit Fittings: NEMA TC 3; match to conduit type and material.

2.03 FITTINGS

A. Fittings and conduit bodies for steel conduits:

1. Steel or malleable iron, zinc galvanized or cadmium plated.
2. Do not use set screw or indentor type fittings.
3. Do not use aluminum or die cast fittings.
4. GRS Connectors and Couplings:

a. Threaded.
b. Insulated throat.
c. Gland compression type.
d. Rain and concrete type.

5. Comply with NEMA FB 1, compatible with conduit materials.

B. Fittings for flexible metal conduit.

1. Insulated throat type.
2. Threaded.
3. Grounding type.
4. Liquidtight: 1 piece sealing "O" rings with connectors when entering boxes or enclosures.
5. Hazardous Locations: Stainless steel.

C. PVC Conduit Fittings:

1. NEMA TC 3; match to conduit type and material.

D. Expansion Joints:

1. Conduit expansion fittings complete with copper bonding jumper, Crouse-Hinds Type XJ.

2. Conduit expansion/deflection fittings with copper bonding jumper, Crouse-Hinds Type XD.

E. Seals:

1. Wall entrance, OZ/Gedney Type FSK or FSC.

F. Drain Fittings:

1. Automatic Drain Breather:

a. Explosionproof.

1) Safe for Class I Division 1, Groups C and D.

b. Capable of passing minimum 25 cubic centimeters of water per minute and minimum 0.05 cubic feet of air per minute at atmospheric pressure.

2. Condensate Drain:

a. Conduit outlet body, Type T.
b. Threaded, galvanized plug with 3/16 inch drilled holed through plug.

G. Hazardous Areas:

1. Explosionproof.
2. Horizontal seal fittings, Crouse-Hinds Type EYS.
3. Vertical seal fittings, Crouse-Hinds Type EYD.
4. Vertical seal fittings shall have drain plug.

2.04 WIREWAYS

A. Material: Sheet metal sized and shaped as indicated.

B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireway as required for complete system.

C. Select features where not otherwise indicated, as required to complete wiring system and to comply with NEC.

D. Wireway Covers:

1. Hinged type for dry locations.
2. Bolted cover with gasket for wet locations.

E. Finish: Manufacturer's standard enamel finish unless otherwise noted.

2.05 RACEWAY/DUCT SEALING COMPOUND

A. Nonhardening, putty-like consistency workable at temperatures as low as 35°F.

B. Compound shall not slump at temperature of 300 °F and shall readily adhere to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

PART 3– EXECUTION

3.01 EXAMINATION

A. Examine surfaces to receive raceways, wireways, and fittings for compliance with installation tolerances and other conditions affecting performance of raceway system.

B. Coordinate layout and installation of raceway and boxes with other construction elements to ensure adequate headroom, working clearance, and access. Coordinate layout and installation of raceway and boxes with light fixtures to ensure raceway and boxes are not mounted lower or below light fixtures causing shadows.

3.02 WIRING METHODS

A. Outdoors, Damp or Wet Locations: Use following wiring methods unless otherwise noted on Drawings:

1. Exposed: PVC-coated steel conduit.
2. Concealed: Galvanized rigid steel.
3. Underground Power and Control, Single Run: Rigid nonmetallic PVC conduit.

    a. Concrete encased except for area lighting branch circuits or as otherwise noted on Drawings.

4. Underground Power and Control, Grouped: Rigid nonmetallic PVC conduit.

    a. Concrete encased.

5. Underground Shielded Instrumentation Cables and Shielded Instrumentation Cables run in concrete slabs, Single Run or Grouped: Galvanized rigid steel.

    a. Concrete encased.

6. Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment): Liquidtight flexible metal conduit.

B. Indoor Dry Locations: Use following wiring methods unless otherwise noted.

1. Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment): Flexible metal conduit.

2. Exposed: galvanized rigid steel conduit.
3. Concealed: galvanized rigid steel conduit.

C. Hazardous classified locations: Use the following wiring methods unless otherwise noted on drawings.

1. Exposed and concealed PVC-coated steel conduit.
2. Exposed flexible conduit: Stainless steel braid suitable for the hazardous classified location.

D. Use 3/4 inch minimum size unless otherwise noted except conduit runs to room light switches may be 1/2 inch.

E. Unless specifically indicated otherwise, use galvanized rigid steel conduit for general wiring.

F. Underground conduits:

1. Encase galvanized rigid steel conduits installed underground in at least 3 inch of concrete.
2. PVC conduit may be used without encasing in concrete for underfloor power and control conduit or where specifically indicated on Drawings.

3. Underground conduit shall be minimum of 1 inch outside of the building and minimum 3/4 inch within the building, buried at depth of not less than 24 inch below grade.
4. Provide conduits or ducts terminating below grade with means to prevent entry of dirt and moisture.
5. When using concrete encased PVC conduit provide PVC coated galvanized rigid steel elbows.

G. In precast areas, run conduits in insulation space or in floor topping without crossing conduits, using 3/4 inch maximum conduit size.

H. Raceways Embedded in Slabs: Install in middle third of slab thickness where practical, and leave at least 1 inch (25 millimeter) concrete cover.

1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
2. Space raceways laterally to prevent voids in concrete.
3. Run conduit larger than 1 inch trade size parallel to or at right angles to main reinforcement and spaced on center of at least 3 times conduit trade diameter with minimum 2 inch concrete covering. Conduits over 1 inch may not be installed in slab without approval of Engineer.
4. When at right angles to reinforcement, place conduit close to slab support.
5. Conduits embedded in concrete frame shall comply with applicable provisions of American Concrete Institute (ACI) 318.

3.03 INSTALLATION

A. Conceal raceways by enclosing within finished walls, ceilings, and floors, unless otherwise indicated.

B. Provide watertight conduit system where installed in wet places, underground or where buried in masonry or concrete.

1. Use threaded hubs when entering top of enclosures.
2. Use sealing type locknuts when entering sides or bottom of enclosures.

C. Install two spare 1 inch conduits from top of each flush mounted panelboard to area above ceiling for future use. On flush mounted panelboards located on first and higher level floors, provide two spare 1 inch conduits from bottom of panelboard to ceiling area of floor below for future use.

D. Keep raceways at least 6 inch (150 millimeter) away from parallel runs of flues and steam or hot water pipes. Install horizontal raceway runs above water and steam piping.

E. Install raceways level and square and at proper elevations. Provide adequate headroom.

F. Complete raceway installation before starting conductor installation.

G. Support raceway as specified in Section 26 05 09.

H. Use temporary closures to prevent foreign matter from entering raceway.

I. Run concealed raceways with minimum of bends in shortest practical distance considering type of building construction and obstructions, except as otherwise indicated.

J. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow surface contours as much as practical.

1. Mount exposed horizontal runs as high above floor as possible, and in no case lower than 7 foot above floors, walkways, or platforms in passage areas.

2. Run parallel or banked raceways together, on common supports where practical.
3. Make bends in parallel or banked runs from same center line to make bends parallel. Use factory elbows only where they can be installed parallel; otherwise, provide field bends for parallel raceways.

K. Join raceways with fittings designed and approved for purpose and make joints tight.

1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
2. Use insulating bushings to protect conductors.

L. Terminations: Where raceways are terminated with locknuts and bushings, align raceway to enter squarely, and install the locknuts with dished part against the box. Use two locknuts, one inside and one outside the box. Use insulating bushings. Provide insulated grounding bushings to terminate ground wire.

M. Where terminating in threaded hubs, screw 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 box, and tighten chase nipple so no threads are exposed.

N. Install pull wires in empty raceways. Use monofilament plastic line having not less than 200 pound (90 kilogram) tensile strength. Leave not less than 12 inch (300 millimeter) of slack at each end of pull wire.

O. Signal System Raceways 2 inch Trade Size and Smaller: In addition to above requirements, install in maximum lengths of 150 foot (45 meters) and with maximum of two 90 degree bends or equivalent. Install pull or junction boxes where necessary to comply with these requirements.

P. PVC Externally Coated Galvanized Rigid Steel Conduit: Use only fittings approved for use with that material. Patch nicks and scrapes in PVC coating after installing conduit.

3.04 CONDUIT STUB-UPS

A. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above finished slab.

B. Transition under floor conduit to PVC coated galvanized rigid steel conduit before rising above floor. Under floor conduit elbows shall be PVC coated galvanized rigid steel conduit. Extend the PVC coated galvanized rigid steel conduit portion of the stub-up minimum 12 inch above floor or slab.

3.05 CONDUIT BENDS

A. Make bends and offsets so inside diameter is not reduced. Unless otherwise indicated, keep legs of bend in same plane and straight legs of offsets parallel.

B. Provide NEMA standard conduit bends, except for conduits containing medium voltage cable, fiber optic cable, or conductors requiring large radius bends.

C. Provide large radius conduit bends for conduits containing 5 kilovolt and 15 kilovolt cables as follows:

Conduit Trade Size	Bend Radius
2 inch - 2-1/2 inch	24 inch
3 inch - 4 inch	36 inch
5 inch	48 inch

1. Where physical limitations do not permit use of above, conduit bends with radius of at 8 times diameter of largest cable passing through conduit may be used.

3.06 FLEXIBLE CONNECTIONS

A. Use maximum of 6 foot (1830 millimeter) of flexible conduit for recessed and semi-recessed lighting fixtures.

B. Terminate conduits at motor terminal boxes, motor operated valve stations or pipe-mounted instruments and other equipment subject to vibration with maximum of 3 foot (915 millimeter) liquidtight flexible metal conduit unless other wise indicated.

C. Use liquidtight flexible conduit in wet or damp locations.

D. Use flexible conduit and connections suitable for hazardous classified locations in hazardous classified locations.

E. Install separate ground conductor inside flexible conduit connections.

3.07 FITTINGS

A. Install raceway sealing fittings according to manufacturer's written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL-listed sealing compound. Install raceway sealing fittings at following points and elsewhere as indicated:

1. Where conduits enter or leave hazardous locations.
2. Where conduits pass from warm locations to cold locations, such as boundaries of refrigerated spaces and air-conditioned spaces.
3. Where otherwise required by NEC.

B. Use raceway fittings compatible with raceway and suitable for use and location. For GRS, use threaded conduit fittings, except as otherwise indicated.

C. Install automatic breather drain fittings according to manufacturers written instructions. Locate fittings to drain conduit system and prevent condensate from entering device enclosures. Install automatic breather drain fittings at following points and elsewhere as indicated.

1. Where vertical seals are installed.
2. Low points in conduit system.
3. Below field instruments at junction of flexible and rigid conduit.
4. Where otherwise required by NEC.

D. Install wall entrance seal as dictated by application where conduits pass through foundation walls below grade.

E. Install conduit expansion fittings complete with bonding jumper in following locations.

1. Conduit runs crossing structural expansion joint.
2. Conduit runs attached to 2 separate structures.
3. Conduit runs where movement perpendicular to axis of conduit may be encountered.

F. Where conduit passes from inside of building to outdoors, it shall be firmly packed at fitting nearest wall line with Johns-Manville Duxseal to depth of at least 1 inch after wires and cables are pulled in; or, if conduit enters directly into equipment, it shall be fitted with seal and drain fitting to prevent water entering equipment.

3.08 GROUNDING

A. Ground in accordance with Section 26 05 26.

B. Provide grounding connections for raceway, boxes, and components as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL 486A.

3.09 PROTECTION

A. Provide final protection and maintain conditions, in manner acceptable to manufacturer and Installer, to ensure that coatings, finishes, and cabinets are without damage or deterioration at Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touch-up coating recommended by manufacturer.

3.10 CLEANING

A. Upon completion of installation of system, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

END OF SECTION

SECTION 26 05 43
UNDERGROUND DUCTS AND MANHOLES FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Ducts.
2. Duct banks.
3. Manholes.

1.02 DEFINITIONS

A. Duct: General term for electrical conduit and other raceway, either metallic or nonmetallic, specified for use underground, embedded in earth or concrete.

B. Duct Bank: Group of 2 or more ducts in continuous run between two points.

C. Underfloor Conduits.

1. Conduits which run underground within perimeter of building walls under building floor. This may consist of 1 conduit, or several conduits grouped together.

D. Duct Bank Conduits

1. Conduits which run underground outside perimeter of building walls. This may consist of 1 conduit, or several conduits grouped together.

E. Underground Conduits

1. Underground conduits are both underfloor conduits and duct bank conduits.

F. Manhole: Below-the-surface enclosure or chamber, large enough for person to enter, connecting with ducts, and affording facilities for installing, operating, and maintaining equipment or wiring.

1.03 SUBMITTALS

A. Submittals identified below are required.

1. Product data.
2. Duct entrances to buildings detailing conduit materials and a sketch showing elevations of conduits in relation to the building floor slabs, footings and frost walls.
3. A buoyancy calculations for each handhole and manhole documenting the following buoyancy criteria is met:

a. Minimum safety factor 1.1
b. Surface friction with backfill materials shall not be included.
c. Submerged soil weight of 55 pounds per cubic foot where soil is used to help hold down the manhole. Only soil above manhole or any anti-flotation devices may be included.
d. Water table to grade.
e. No water weight to be included inside structure.
f. Weight for castings, all precast components and any manufacturer supplied fillets in bottom of manhole may be included.

4. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturers of precast manholes and handholes shall be firms regularly engaged in manufacturing factory-fabricated manholes and handholes, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in OSHA Regulation 1910.7.

2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

C. Regulatory Requirements:

1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store precast concrete units at site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

B. Lift and support precast concrete units only at designated lifting or supporting points.

1.06 SEQUENCING AND SCHEDULING

A. Coordination of Work:

1. Coordinate layout and installation of manholes and handholes with final arrangement of ducts as influenced by actual final location of other utilities in field.
2. Coordinate elevations of duct and raceway entrances into manholes and handholes with final profiles of ducts and raceways as determined by coordination with other utilities, underground obstructions, and buildings.
3. Establish locations and elevations to suit field conditions and assure duct runs drain to manholes, handholes, or as shown on Drawings.

PART 2 – PRODUCTS

2.01 DUCTS AND FITTINGS

A. Comply with Section 26 05 33.16.

2.02 CAST-IN-PLACE CONCRETE

A. Comply with Section 03 30 00 for concrete and Section 03 20 00 for reinforcing.

B. Aggregate For Duct Encasement: 3/8 inch maximum size.

C. Strength: 3,000 pounds per square inch (psi) minimum 28 day compressive strength.

D. Top layer of concrete encased conduit duct bank shall be dyed red.

2.03 DUCT BANK ACCESSORIES

A. Duct Supports: Rigid Polyvinyl Chloride (PVC) spacers selected to provide minimum duct spacings and concrete cover depths indicated, while rigidly supporting ducts during concreting.

2.04 MANHOLE/HANDHOLE HARDWARE AND ACCESSORIES

A. Frames and Covers: Cast iron conforming to American National Standards Institute (ANSI) C2, Rule 323. Truck traffic rated. Furnish with cast-in legend, "Electric" or "Signal" as appropriate. Cover-to-frame bearing surfaces machined. Provide gasketed watertight manhole cover.

B. Sump Frame and Grate: Comply with FS RR-F-621, Type VII for frame, Type I for cover.

C. Pulling Eyes in Walls: Eyebolt with rebar fastening insert. 2 inch diameter eye, 1 inch by 4 inch long bolt. Working load embedded in 6-inch, 4,000 psi concrete: 13,000 pounds minimum tension.

D. Pulling and Lifting Irons in Floor: 7/8 inch diameter hot-dipped galvanized, bent steel rod, stress relieved after forming, and fastened to reinforced rod. Exposed triangular shaped opening. Ultimate yield strength, 40,000 pounds shear, 60,000 pounds tension.

E. Expansion Anchors for Installation after Concrete is cast: Zinc-plated carbon steel wedge type with stainless steel expander clip 1/2 inch bolt size, 5,300 pound rated pull-out strength, and 6,800 pound rated shear strength, minimum.

F. Cable Racks and Arms: Heavy duty nonmetallic cable racks and arms with comparable loading capacity as steel cable racks and arms. Provide adequate quantity of cable racks and arms to train conductors around perimeter of manholes and support the weight of the cables in the manholes plus 33% extra weight capacity and arm capacity for future cables.

G. Ground Rods: Solid copper clad steel, 3/4 inch diameter by 10 foot length.

H. Ground Wire: Stranded bare copper, No. 6 American Wire Gauge (AWG), minimum.

2.05 PRECAST MANHOLES AND HANDHOLES

A. Factory fabricated of reinforced concrete in conformance with ANSI C2 and applicable requirements of American Society for Testing and Materials (ASTM) C478. Design manhole structure in accordance with requirements of American Association of State Highway and Transportation Officials (AASHTO) publication "Standard Specifications for Highway Bridges." AASHTO H20 highway loading shall apply with 30% loading added for impact.

B. Precast Units: Interlocking, mating sections, complete with accessory items, hardware, and features as indicated including concrete knockout panels for conduit entrance and sleeve for ground rod.

C. Joint sealant for joints between precast sections shall be continuous extrusion of asphaltic butyl material compounded for adhesion, cohesion, flexibility, and durability properties required for permanent seal against maximum hydrostatic pressures theoretically attainable at installation location with ground water level at grade.

2.06 RACEWAY/DUCT SEALING COMPOUND

A. Compound:

1. Nonhardening, putty-like consistency workable at temperatures as low as 35 degrees Fahrenheit.
2. Compound shall not slump at temperature of 300 degrees Fahrenheit and shall readily adhere to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

PART 3 – EXECUTION

3.01 WIRING METHOD

A. General: Install ducts for wiring runs indicated. Provide sizes as indicated.

B. Single Lighting Duct Runs: Rigid nonmetallic PVC conduit, Schedule 40, encased in concrete unless otherwise noted.

C. Duct Banks:

1. Power and Control Conduits: Rigid nonmetallic conduit, Schedule 40, encased in concrete.
2. Instrumentation Conduits: Galvanized Rigid Steel conduit encased in concrete.

3.02 EXCAVATION AND BACKFILL

A. Conform to Section 31 23 00 except as modified below:

1. Do not use heavy-duty, hydraulic-operated compaction equipment.
2. Excavation: Cut trenches neatly and uniformly, and slope uniformly to required pitch.
3. For direct-buried, nonencased ducts prepare trench bottoms free from stones, soft spots, and sharp objects. Where necessary, add 3 inch layer of stone-free sand or earth to trench bottom and compact to density of adjacent undisturbed soil to provide suitable bearing for ducts. Backfill over and around ducts on bottom of trench with stone-free sand or earth to 6 inch minimum above tops of ducts and compact by hand or pneumatic tamper to density of adjacent undisturbed earth.
4. For each additional layer of direct-buried ducts above bottom ducts, backfill over and around each layer of ducts with stone-free sand or earth to 12 inch minimum above tops of ducts and compact by hand or pneumatically to density of adjacent undisturbed earth.
5. Separation Between Direct-Buried, Nonencased Ducts: 3 inch minimum for like services, and 6 inch minimum between power and signal ducts.

3.03 INSTALLATION OF DUCTS

A. Slope: Pitch ducts to drain away from buildings and equipment unless otherwise shown on Drawings. Minimum slope shall be 4 inch in 100 foot Where necessary to achieve this between manholes, slope ducts from high point in run to drain in both directions.

B. Curves and Bends: Use manufactured elbows for stub-ups at equipment and at building entrances. For other curves and bends, except as otherwise indicated, use manufactured long sweep bends with minimum radius of 36 inches in both horizontal and vertical directions. Conduit elbows in duct banks shall be PVC coated galvanized rigid steel.

C. Make joints in ducts and fittings watertight in accordance with manufacturer's instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

D. Duct Entrances to Buildings: Transformations from underground PVC duct to steel conduit shall be made 10 foot minimum unless otherwise indicated on drawings, outside building wall and shall use fittings manufactured for purpose. Install in accordance with following:

1. Concrete-Encased Ducts: Install reinforcing in duct banks and coordinate duct bank with structural design at wall so duct bank is supported at wall without reducing structural or watertight integrity.
2. Direct-Buried, Nonencased Duct Entering Nonwaterproofed Walls: Install Schedule 40 galvanized steel pipe sleeve for each duct. Caulk space between conduit and sleeve with duct sealing compound on both sides for moisture-tight seal.
3. Waterproof Entrances: Where ducts enter buildings through waterproofed floor or wall, watertight entrance-sealing device shall be installed with sealing gland assembly on inside. Anchor device securely into masonry construction with one or more integral flanges and membrane waterproofing secured to device in permanently watertight manner.

E. Concrete-Encased Ducts: Support on plastic separators coordinated with duct size and required duct spacing, and install in accordance with following:

1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, and secure separators to earth and to ducts to prevent floating during concreting. Do not use tie wires or reinforcing steel in such way as to form conductive or magnetic loops around ducts or duct groups.
2. Reinforcing: Reinforce duct banks. Size and arrange reinforcing steel as indicated on Drawings.
3. Concreting: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not use power-driven agitating equipment unless specifically designed for duct bank application. Pour each run of envelope between manholes or other terminations in one continuous operation unless approved by Engineer. Where more than one pour is necessary, terminate each pour in vertical plane and continue duct bank reinforcing minimum of 18 inch beyond termination of pour. Top layer of concrete encased conduit duct bank shall be dyed red.
4. Forms: Walls of trench may be used to form side walls of duct bank provided soil is self-supporting and concrete envelope can be poured without soil inclusions. Use forms where soil is not self-supporting.
5. Minimum Clearances: 3 inch between ducts and exterior envelope wall, 3 inch between ducts for like services, and 6 inch between power and ducts for other systems.
6. Depth: Except as otherwise indicated, top of duct bank shall be 24 inch below finished grade, minimum, in nontraffic areas, and 30 inch below finished grade, minimum, in vehicular traffic areas.

F. Stub-ups: Duct stub-ups to equipment shall be PVC coated galvanized rigid steel. For equipment mounted on outdoor concrete pads, PVC coated rigid steel conduit shall extend minimum of 5 foot away from edge of pad. Install insulated grounding bushings on terminations. Couple steel conduits to ducts with adapters designed for purpose and encased concrete.

G. Sealing: For ducts to be wired in this Project, provide temporary closure at terminations. For spare ducts, seal bore of ducts at terminations. Use sealing compound and plugs as required to withstand 15 psi minimum hydrostatic pressure.

H. Pulling Cord: Provide 100 pound test nylon cord in ducts including spares.

I. Marker Tape: Provide plastic marker tape over ducts at 12 inch below finished grade in accordance with Section 26 05 53.

3.04 INSTALLATION OF MANHOLES/HANDHOLES, GENERAL

A. General:

1. Provide manholes/handholes of sizes, shapes, and locations as indicated.

2. Determine final elevation of ducts as influenced by possible adjustments in other utilities and surface features and discovery of underground obstructions before installing manholes/handholes. Obtain Engineer's approval for manhole/ handhole installation adjustments necessitated by obstructions.
3. Install units plumb and level and with orientation and depth coordinated with arrangement of connecting ducts to minimize bends and deflections required for proper entrances.

B. Elevation:

1. Manholes: Install with roof top 1 inch above finished grade. In roads install flush with road.

C. Access: Install access to manhole/handhole through cast-iron frame and cover. For manholes, use 32 inch gasketed cover except as indicated. Set frames in paved areas and traffic ways flush with finished grade. Set other frames 1 inch above finished grade.

D. Waterproofing: Apply waterproofing to exterior surfaces of units after concrete has cured at least 3 days. After ducts have been connected and grouted in, and prior to backfilling, waterproof joints and connections and touch up abrasions and scars.

E. Hardware: Install removable hardware including pulling eyes and cable racks and arms as required for installation and support of cable and conductors. Provide adequate quantity of cable racks and arms to train conductors around perimeter of manholes and support the weight of the cables in the manholes plus 33% extra weight capacity and arm capacity for future cables.

F. Field-Installed Bolting Anchors: Do not drill deeper than 3-7/8 inch for anchor bolts installed in field. Use minimum of 2 anchors for each cable stanchion.

G. Grounding: Install ground rod through floor of each manhole/handhole with top protruding 4 inch above floor. Seal floor opening against water penetration with waterproof nonshrink grout. Ground exposed metal components and hardware with bare copper ground conductor. Train conductors neatly around corners. Install on walls and roof using cable clamps secured with expansion anchors.

3.05 INSTALLATION OF PRECAST MANHOLES/HANDHOLES

A. Install in accordance with ASTM C891 and manufacturer's instructions.

B. Support units on 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.

3.06 TESTING

A. Field Quality Control:

1. Grounding: Test manhole grounding provisions to ensure electrical continuity of bonding and grounding connections. Make ground-resistance test at each ground rod and submit report of results. Use an instrument specifically designed for ground-resistance measurements.
2. Duct Integrity: Rod ducts with mandrell 1/4 inch smaller in diameter than internal diameter of ducts. Where rodding indicates obstructions in ducts, remove obstructions and retest.
3. Water Tightness: Make internal inspection of manholes/handholes three months after completion of construction for indications of water ingress. Where leakage is noted, remove water found and seal leakage sources. Reinspect after two months and reseal remaining leakage sources. Repeat process at two month intervals until leakage is corrected.

3.07 CLEANING AND RESTORATION

A. Clean Ducts: Clean full length of ducts with round bristle brush with diameter 1/2 inch greater than internal diameter of duct.

B. Clean Manholes: Clean internal surfaces of manholes including sump. Remove foreign materal.

3.08 RESTORATION

A. Restore surface features at areas disturbed by excavation and reestablish original grades except as otherwise indicated.

B. Where sod has been removed, replace it as soon as possible after backfilling is completed.

C. Restore all areas disturbed by trenching, storing of dirt, cable laying, and other work to their original condition.

D. Include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.

E. Restore disturbed paving as indicated.

END OF SECTION

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SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1– GENERAL

1.01 SUMMARY

A. Section Includes:

1. Identification of electrical materials, equipment, and installations.

1.02 SUBMITTALS

A. Product Data:

1. Submit for each type of product specified.

B. Miscellaneous:

1. Schedule of identification nomenclature to be used for identification signs and labels.

C. Submit in accordance with Section 01 33 00.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements:

1. National Electrical Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70.

PART 2– PRODUCTS

2.01 RACEWAY AND CONDUCTOR LABELS

A. Manufacturer's Standard Products: Where more than one type is listed for specified application, selection is Installer's option, but provide a single type for each application category. Use colors prescribed by American National Standards Institute (ANSI) A13.1, NFPA 70, or as specified elsewhere.

B. Conform to ANSI A13.1, Table 3, for minimum size of letters for legend and minimum length of color field for each raceway or cable size.

1. Color: Black legend on orange field.
2. Legend: Indicates voltage.

C. Adhesive Labels: Preprinted, flexible, self adhesive vinyl. Legend is over-laminated with clear, wear and chemical resistant coating.

D. Pre-tensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color coded, acrylic or latex bands sized to suit diameter of line it identifies and arranged to stay in place by pre-tensioned gripping action when placed in position.

E. Colored Adhesive Tape: Self adhesive vinyl tape not less than 3 mils thick by 1 to 2 inch wide (0.08 millimeter thick by 25 to 51 millimeter wide).

F. Underground Line Warning Tape: Permanent, bright colored, continuous printed, vinyl tape with following features:

1. Size: Not less than 6 inch wide by 4 mils thick (152 millimeter wide by 0.102 millimeter thick).
2. Compounded for permanent direct burial service.
3. Embedded continuous metallic strip or core.
4. Printed Legend: Indicates type of underground line.

G. Aluminum, Wraparound Marker Bands: Bands cut from 0.014 inch (0.4 millimeter) thick aluminum sheet, with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.

H. Plasticized Card Stock Tags: Vinyl cloth with preprinted and field printed legends. Orange background, except as otherwise indicated, with eyelet for fastener.

I. Aluminum Faced Card Stock Tags: Wear resistant, 18 point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 inch (0.05 millimeter) thick, laminated with moisture resistant acrylic adhesive, and punched for fastener. Preprinted legends suit each application.

J. Brass or Aluminum Tags: Metal tags with stamped legend, punched for fastener. Dimensions: 2 by 2 inch (51 by 51 millimeter) by 0.05 inch (1.3 millimeter).

2.02 ENGRAVED NAMEPLATES AND SIGNS

A. Manufacturer's Standard Products: Where more than one type is listed for specified application, selection is Installer's option, but provide single type for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, or as specified elsewhere.

B. Engraving stock, melamine plastic laminate, 1/16 inch (1.6 millimeter) minimum thick for signs up to 20 square inch (129 square cm), 1/8 inch (3.2 millimeter) thick for larger sizes.

1. Engraved Legend: Black letters on white face.
2. Punched for mechanical fasteners.

C. Baked Enamel Signs for Interior Use: Preprinted aluminum signs, punched for fasteners, with colors, legend, and size as indicated or as otherwise required for application. 1/4 inch (6.4 millimeter) grommets in corners for mounting.

D. Exterior, Metal Backed, Signs: Wear resistant, non-fading, UV resistant ink, with reinforced UV, chemical, abrasion, and moisture resistant laminate layer. Aluminum substrate 0.04 inch (1 millimeter), with colors, legend, and size appropriate to application. 1/4 inch (6.4 millimeter) grommets in corners for mounting.

E. Fasteners for Plastic Laminated and Metal Signs: Self tapping stainless steel screws or No. 10/32 stainless steel machine screws with nuts, flat washers and lock washers.

2.03 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self extinguishing, 1 piece, self locking, Type 6/6 nylon cable ties with following features:

1. Minimum Width: 3/16 inch (5 millimeter).
2. Tensile Strength: 50 pound (22.3 kilograms) minimum.
3. Temperature Range: Minus 40 to 185 degrees Fahrenheit (Minus 4 to 85 degrees Celsius).
4. Color: As indicated where used for color coding.

B. Paint: Alkyd-urethane enamel. Primer as recommended by enamel manufacturer.

PART 3– EXECUTION

3.01 INSTALLATION

A. Install identification devices according to manufacturer's written instructions.

B. Install labels where indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

C. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and or designations used for electrical identification with corresponding designations used in Contract Documents or required by codes and standards. Use consistent designations throughout Project.

D. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

E. Self Adhesive Identification Products: Clean surfaces of dust, loose material, and oily films before applying.

F. Identify feeders over 600 volt with "DANGER-HIGH VOLTAGE" in black letters 2 inch (51 millimeter) high, stenciled with paint at 10 feet (3 meter) intervals over continuous, painted orange background. Identify following:

1. Entire floor area directly above conduits running beneath and within 12 inch (305 millimeter) of basement or ground floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to conduits concealed within wall.
3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in building, or concealed above suspended ceilings.
4. Entire surface of exposed conduits.

G. Install painted identification as follows:

1. Clean surfaces of dust, loose material, and oily films before painting.
2. Prime Surfaces. For galvanized metal, use single component, acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units, use heavy duty, acrylic resin block filler. For concrete surfaces, use clear, alkali resistant, alkyd binder type sealer.
3. Apply one intermediate and one finish coat of silicone alkyd enamel.
4. Apply primer and finish materials according to manufacturer's instructions.

H. Identify Raceways and Exposed Cables of Certain Systems with Color Banding: Band exposed and accessible raceways of systems listed below for identification.

1. Bands: Pre-tensioned, snap around, colored plastic sleeves; colored adhesive tape; or combination of both. Make each color band 2 inch (51 millimeter) wide, completely encircling conduit, and place adjacent bands of 2 color markings in contact, side by side.
2. Locate bands at changes in direction, at penetrations of walls and floors, at 50 feet (15 meter) maximum intervals in straight runs, and at 25 feet (7.6 meter) in congested areas.
3. Colors: As follows:

    a. Fire Alarm System: Red.

I. Install Caution Signs for Enclosures Over 600 volts: Use pressure sensitive, self-adhesive label indicating system voltage in black, preprinted on orange field. Install on exterior of door or cover.

J. Install Circuit Identification Labels on Boxes: Label externally as follows:

1. Exposed Boxes: Pressure sensitive, self adhesive plastic label on cover.
2. Concealed Boxes: Plasticized card stock tags.
3. Labeling Legend: Permanent, water proof listing of panel and circuit number or equivalent.

K. Identify Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communications lines, install continuous underground plastic line marker located directly above line at 6 to 8 inch (150 to 200 millimeter) below finished grade. Where multiple lines installed in common trench or concrete envelope provide multiple underground line warning tapes, one for each 16 inches of width of lines. If lines do not exceed an overall width of 16 inch (400 millimeter), use single line marker.

1. Install line marker for underground wiring, both direct buried and in raceway.

L. Color Code Conductors: Secondary service, feeder, and branch circuit conductors throughout secondary electrical system.

1. Field applied, color coding methods may be used in lieu of factory coded wire for sizes larger than No. 10 AWG.

   a. Colored, pressure sensitive plastic tape in half lapped turns for distance of 6 inch (150 millimeter) from terminal points and in boxes where splices or taps are made. Apply last 2 turns of tape with no tension to prevent possible unwinding. Use 1 inch (25 millimeter) wide tape in colors as specified. Adjust tape bands to avoid obscuring cable identification markings.
   b. Colored cable ties applied in groups of 3 ties of specified color to each wire at each terminal or splice point starting 3 inch (76 millimeter) from terminal and spaced 3 inch (76 millimeter) apart. Apply with special tool or pliers, tighten to snug fit, and cut off excess length.

2. 208/120 Volt System: As follows:

   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
   d. Neutral: White.
   e. Ground: Green.

3. 480/277 Volt System: As follows:

   a. Phase A: Brown.
   b. Phase B: Orange.
   c. Phase C: Yellow.
   d. Neutral: White with non-green stripe.
   e. Ground: Green.

M. Power Circuit Identification: Use metal tags or aluminum wraparound marker bands for cables, feeders, and power circuits in vaults, pull boxes, junction boxes, manholes, and switchboard rooms.

1. Legend: 1/4 inch (6.4 millimeter) steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
2. Fasten tags with nylon cable ties; fasten bands using integral ears.

N. Apply identification to conductors as follows:

1. Conductors to Be Extended in Future: Indicate source and circuit numbers.
2. Multiple Power or Lighting Circuits in Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color coding for voltage and phase indication of secondary circuit.
3. Multiple Control and Communications Circuits in Same Enclosure: Identify each conductor by its system and circuit designation. Use consistent system of tags, color coding, or cable marking tape.

O. Apply warning, caution, and instruction signs and stencils as follows:

1. Install warning, caution, and instruction signs where indicated or required to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved, plastic laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.
2. Emergency Operating Signs: Install engraved laminate signs with white legend on red background with minimum 3/8 inch (9 millimeter) high lettering for emergency instructions on power transfer, load shedding, and or emergency operations.

P. Install identification as follows:

1. Apply equipment identification labels of engraved plastic laminate on each major unit of equipment, including central or master unit of each system. This includes communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Except as otherwise indicated, provide single line of text with 1/2 inch (13 millimeter) high lettering on 1-1/2 inch (38 millimeter) high label; where 2 lines of text are required, use lettering 2 inch (51 millimeter) high. Use black lettering on white field. Apply labels for each unit of following categories of equipment.

    a. Panelboards, electrical cabinets, and enclosures.
    b. Access doors and panels for concealed electrical items.
    c. Electrical switchgear and switchboards.
    d. Motor control centers.
    e. Motor starters.
    f. Push button stations.
    g. Contactors.
    h. Remote controlled switches.
    i. Control devices.
    j. Transformers.
    k. Fire alarm master station or control panel.

2. Apply designation labels of engraved plastic laminate for disconnect switches, breakers, push buttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

END OF SECTION

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SECTION 26 05 73
POWER SYSTEM STUDIES

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Short circuit study, protective device evaluation study, protective device coordination study, and arc flash study on electrical power distribution system. Study shall include all new electrical equipment, existing Switchgear 3-6, and existing 12.47KV transformers 3 and 6.
2. Portions of electrical distribution system from normal and alternate sources of power throughout distribution system. Normal system operating method, alternate operation, and operations which could result in maximum fault conditions and maximum incident energy shall be covered in study.

B. Contractor shall engage services of independent engineering firm for purpose of performing electric power system studies as specified.

C. The Electrical Power System Studies shall be performed and the shop drawing shall be submitted and approved prior to submitting the shop drawings for the electrical equipment.

1.02 SUBMITTALS

A. Study Report:

1. Provide summary of results of power system study in final report. Submit 5 bound copies of final report.
2. Include:

a. Description, purpose, basis, and scope of study and single line diagram of power system.
b. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short circuit duties and commentary regarding same.
c. Protective device time versus current color coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection, and commentary regarding same.
d. Fault current calculations including definition of terms and guide for interpretation of computer printout.
e. Tabulation of appropriate tap settings for relay units.
f. Arc flash calculations and tabulation of incident energy level calories /square centimeter (cal/cm^2) for each equipment location and recommended personal protective equipment (PPE).

B. Electronic Model. Upon approved report, files for electronic model to be compatible with EasyPower software shall be delivered to Four Rivers Sanitary District on a flash drive.

C. Submit in accordance with Section 01 33 00.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements:

1. National Electric Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70.

2. National Electric Safety Code (NESC): Components and installation shall comply with American National Standards Institute (ANSI) C2.

3. Standard for Electrical Safety in the Work Place: National Fire Protection Association (NFPA) 70E.

B. Qualifications of engineering firm.

1. Corporately and financially independent engineering organization which can function as unbiased engineering authority, professionally independent of manufacturers, suppliers and installers of equipment or systems studied as specified.
2. Study report shall be signed and sealed by Professional Engineer registered in same State as project location.
3. Engineering organization may be same as testing organization.

PART 2 – PRODUCTS

2.01 SOFTWARE

A. EasyPower.
B. No Substitutes.

PART 3 – EXECUTION

3.02 STUDIES

A. Studies include following.

1. Utility Company incoming service lines.
2. Main switching station.
3. Power transformers.
4. Medium to low voltage switchgear.
5. Motor control centers.
6. Power and lighting distribution panels.
7. Cable, wire, and conduit systems.

B. Studies do not include equipment as shown on Drawings indicated as future.

C. Contractor and company performing the power system studies are responsible for gathering information on the equipment and conductors required to perform the power system studies.

3.03 SHORT CIRCUIT STUDY

A. Provide complete report with printout data sheets using digital computer type program as part of study.

B. Include utilities' short circuit contribution, resistance and reactance components of branch impedances, X/R ratios, base quantities selected, and other source impedances.

C. Calculate short circuit momentary duty values and interrupting duty values based on assumed 3-phase bolted short circuit at switch gear base medium voltage controller, switchboard, low voltage Motor Control Center (MCC), distribution panelboard, pertinent branch circuit panel, and other significant locations through system. Include short circuit tabulation of symmetrical fault currents and X/R ratios. List with respective X/R ratio each fault location, total duty on bus, and individual contribution from each connected branch.

3.04 EQUIPMENT DEVICE EVALUATION STUDY

A. Provide protective device evaluation study to determine adequacy of circuit breakers, molded case switches, automatic transfer switches, knife switches, controllers, surge arresters, busways, and fuses by tabulating and comparing short circuit ratings of these devices with calculated fault currents. Apply appropriate multiplying factors based on system X/R ratios and protective device rating standards. Notify Engineer of problem areas or inadequacies in equipment due to short circuit currents and provide suggested alternate equipment.

3.05 EQUIPMENT DEVICE COORDINATION STUDY

A. Provide protective device coordination study with necessary calculations and logic decisions required to select or check selection of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low voltage breaker trip characteristics and settings. Objective of study to obtain optimum protective and coordination performance from these devices.

B. Include as part of coordination study, medium and low voltage classes of equipment from utility's incoming line protective device down to and including largest rated device in 480 volt MCCs and panelboards. Include phase and ground overcurrent protection as well as settings of other adjustable protective devices.

C. Draw time-current characteristics of specified protective devices in color on log-log paper or computer printout. Include with plots complete titles, representative one-line diagram and legends, associated Power Company's relays or fuse characteristics, significant motor starting characteristics, complete parameters of transformers, complete operating bands of low voltage circuit breaker trip curves and fuses. Indicate types of protective devices selected, proposed relay taps, time dial and instantaneous trip settings, transformer magnetizing in-rush and ANSI transformer withstand parameters, cable thermal overcurrent withstand limits, and significant symmetrical and asymmetrical fault currents. Provide coordination plots for phase and ground protective devices on system basis. Provide sufficient number of separate curves to indicate coordination achieved.

D. Provide separate selection and settings of protective devices in tabulated form listing circuit identification, Institute of Electrical and Electronics Engineers (IEEE) device number, current transformer ratios and connection, manufacturer and type, range of adjustment, and recommended settings. Tabulate recommended power fuse selection for medium voltage fuses where applied in system. Notify Engineer of discrepancies, problem areas or inadequacies and provide suggested alternate equipment ratings and/or settings.

3.06 ARC FLASH STUDY

A. Provide Incident Energy Study – An incident energy study shall be done in accordance with the IEEE 1584, ”IEEE Guide for Performing Arc Flash Hazard Calculations” as referenced in NFPA 70E, “Standard for Electrical Safety in the Workplace”, in order to quantify the hazard for selection of personal protective equipment (PPE).

B. Adjust system design to optimize the results of the study as it relates to safety and reliable electrical system operation (e.g. overcurrent device settings, current limiting devices). This includes mitigation, where possible, of incident energy levels that exceed 40 cal/cm^2. Provide suggested alternate equipment and settings to minimize incident energy levels.

C. Provide incident energy level (cal/cm^2) for each equipment location and recommended PPE.

D. Based on the results of the incident energy study provide and install a warning label (orange <40 cal/cm^2) or danger label (red > 40 cal/cm^2) for each piece of equipment. The label must be readable in both indoor and outdoor environments and contain the following information:

1. Arc hazard boundary (feet and inches)

2. Working distance (feet and inches)
3. Arc flash incident energy at the working distance (cal/cm^2)
4. Voltage rating of the equipment
5. Limited approach distance (feet and inches)
6. Restricted approach distance (feet and inches)
7. Equipment/bus name
8. Date prepared

3.07 PROTECTIVE DEVICE TESTING, CALIBRATION, AND ADJUSTMENT

A. Comply with Section 26 01 26.

END OF SECTION

SECTION 26 05 84
ELECTRIC MOTORS

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Electric motors for use on ac power systems up to 600 Volts.
2. Motors that are factory-installed as part of equipment.
3. Field-installed motors.

B. Motors furnished under other sections of these Specifications as part of equipment items shall conform to requirements of this section except as noted otherwise in that section or indicated otherwise on Drawings or schedules.

C. Section does not include manufacturer's definite purpose, direct current, synchronous or wound rotor motors.

1.02 SUBMITTALS

A. General:

1. Include motor submittal as part of equipment submittal for equipment specified in other sections.
2. Include identification of equipment by name and tag number as indicated in Specifications or on Drawings.

B. Product Data:

1. Complete nameplate data in accordance with National Electrical Manufacturers Association (NEMA) standards.
2. Full load power factor and maximum recommended power factor correction capacitor kilovolt amperes reactive (kVAr) rating for motors 5 horsepower and larger.
3. Nominal efficiency in accordance with Institute of Electrical and Electronics Engineers (IEEE) 112.
4. Motor dimensions and frame size.
5. Manufacturer's printed data on each motor type being provided to indicate compliance with specified performance and construction.
6. Service manual to include storage and alignment instructions.

C. Submit in accordance with Section 01 33 00.

D. Operation and Maintenance (O&M) Data:

1. Operating instructions, maintenance requirements and parts list.
2. Submit with specification section of equipment of which motor is a part.
3. Submit in accordance with Section 01 78 23.

1.03 QUALITY ASSURANCE

A. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).

1. Terms "NRTL" shall be as defined in OSHA Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code, Article 100.

B. Comply with National Electrical Manufacturers Association (NEMA) MG 1, "Motors and Generators."

C. Comply with UL 1004, "Motors, Electric".

PART 2 – PRODUCTS

2.02 MANUFACTURERS

A. Siemens

B. General Electric

C. U.S. Motors

D. Toshiba

E. WEG

2.03 GENERAL

A. Requirements below apply to motors covered by this Section except as otherwise indicated.

B. Motors 1/2 horsepower and Larger: Polyphase.

C. Motors Smaller Than 1/2 horsepower: Single-phase.

D. Frequency Rating: 60 Hertz.

E. Voltage Rating: Determined by voltage of circuit to which motor is connected for following motor voltage ratings (utilization voltages):

1. 120 volt Circuit: 115 volt - motor rating.
2. 208 volt Circuit: 200 volt - motor rating.
3. 240 volt Circuit: 230 volt - motor rating.
4. 480 volt Circuit: 460 volt - motor rating.

F. Service factors indicated for motors are minimum values and apply at frequency and utilization voltage at which motor is connected. Provide motors which will not operate in service factor range when supply voltage is within 10% of motor voltage rating.

G. Capacity: Sufficient to start and operate connected loads at designated speeds in indicated environment, and with indicated operating sequence, without exceeding nameplate ratings. Provide motors rated for continuous duty at 100% of rated capacity.

H. Temperature Rise: Based on 40 degrees Celsius ambient except as otherwise indicated.

I. Enclosure: Totally Enclosed Fan Cooled (TEFC) unless otherwise indicated in other sections and as required by NEC.

1. Explosion proof motors approved for specific hazard classifications covered by NEC.
2. Weather proof motors designed for outdoors and in wet areas.
3. Chemical resistant motors designed for severe duty applications, including high humidity, corrosive, dirty or salty atmospheres.

J. Copper Windings.

2.04 POLYPHASE MOTORS

A. Squirrel-cage induction-type conforming to following requirements except as otherwise indicated.

B. NEMA Design Letter Designation: "B"

C. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading for application.

D. Motor Efficiencies:

1. General purpose motors (not inverter duty/vector duty or explosion proof): NEMA Premium Energy Efficient Motors with nominal efficiency equal to or greater than that stated in NEMA MG 1 for NEMA Premium Energy Efficient Motors for that type and rating of motor.
2. Inverter Duty and/or Vector Duty Motors: NEMA Premium Energy Efficient Motors with nominal efficiency equal to or greater than that stated in NEMA MG 1 for NEMA Premium Energy Efficient Motors for that type and rating of motor.
3. Explosion proof motors: NEMA Premium Energy Efficient Motors with nominal efficiency equal to or greater than that stated in NEMA MG 1 for NEMA Premium Energy Efficient Motors for that type and rating of motor.

E. Inverter Duty and/or Vector Duty Motors with Manufacturer's Premium Insulation System that is Specifically for Use with Solid-State Drives/ Variable Frequency Drives (VFD): Squirrel-cage induction, NEMA Design B units with ratings, characteristics, and features coordinated with and approved by drive manufacturer conforming to or exceeding the requirements of NEMA MG 1, Part 31.

1. Include adequate thermal capacity for continuous operation under worst case temperature conditions with motor operating at rated torque, without reduction in insulation life of motor, under the range of conditions specified.
2. Suitable for operation with inverters specified in Section 26 29 23.

3. Motors operating on VFD shall be protected from circulating shaft currents with either a grounding ring or insulated bearings:

a. Provide factory installed motor shaft grounding ring:

1) AEGIS SGR grounding ring or equal bolted to motor frame
2) Sized for motor shaft.

b. Provide factory installed insulated motor bearing on non-drive end of motors installed in hazardous classified locations.

F. Internal Thermal Overload Protection for Motors: For motors so indicated, protection automatically opens control circuit arranged for external connection. Protection operates when winding temperature exceeds safe value calibrated to temperature rating of motor insulation.

G. Motors for Reduced Inrush Starting: Coordinate with indicated reduced inrush controller type and with characteristics of driven equipment load. Provide required wiring leads in motor terminal box to suit control method.

H. Torque:

1. Breakdown torque shall be 200% or more of maximum torque load placed on motor shaft.
2. Provide necessary WK2 curves for special loads to coordinate with motors.
3. Supply special motors where load requirements exceed standard design.

I. Totally Enclosed Fan Cooled (TEFC) and Totally Enclosed Non Ventilated (TENV).

1. Energy Efficient.
2. 1.15 service factor, Class "F" insulation.
3. Cast iron construction; frame, conduit box, end shields, fan cover, inner caps for 182T frames and larger.
4. Positive lubrication systems.
5. Removable eyebolt.
6. Suitable for indoor and outdoor installations.
7. Diagonally split, neoprene gasketed, rotatable oversized conduit box with NPT threaded lead hole.
8. Conduit box mounted, UL approved clamp type grounding lug.
9. Permanently numbered non-wicking leads.
10. Rust inhibitive non-washing lubricant.
11. Stainless steel nameplate with.

    a. NEMA nominal efficiency.
    b. Anti Friction Bearing Manufacturers Association (AFBMA) bearing numbers.
    c. Lubrication instructions.

J. Explosion Proof.

1. Same features as TEFC.
2. Approved for NEC hazardous classified location as noted in equipment specification or as indicated on Drawings.
3. Automatic explosion proof breather drains.

K. Submersible pump and mixer motors.

1. As specified in equipment specification sections.
2. 1.10 service factor, unless otherwise indicated in equipment specification sections.

2.05 SOURCE QUALITY CONTROL

A. Testing:

1. Perform individual motor test on motors over 1 horsepower.
2. Test shall be standard NEMA routine production test in accordance with NEMA MG 1.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Field install motors in accordance with manufacturer's instructions and following:

1. Direct Connected Motors: Mount securely in accurate alignment.
2. Belt Drive Motors: Use adjustable motor mounting bases. Align pulleys and install belts. Use belts furnished by manufacturer and tension belts in accordance with manufacturer recommendations.

3.02 COMMISSIONING

A. Check operating motors, both factory and field-installed, for unusual conditions during normal operation. Coordinate with commissioning of equipment for which motor is part.

B. Report unusual conditions.

C. Correct deficiencies of field-installed units.

3.03 ALIGNMENT

A. Installer of motor is responsible for alignment.

B. Check alignment of motors prior to startup.

C. Motors over 50 horsepower: Laser alignment and balance check using test equipment specially designed for this purpose.

3.04 FIELD QUALITY CONTROL

A. Inspect wire and connections for physical damage and proper connection.

B. Conduct insulation resistance (megger) test on each motor 25 horsepower and larger before energizing. Conduct test with 500 or 1,000 volts direct current megger. Test each phase separately and follow procedures listed below.

1. Disconnect voltage sources, lightning arrestors, capacitors, and other potential low insulation sources from motor before connecting megger to motor.
2. When testing phase, connect phases not under test to ground.
3. Apply test voltage, phase to ground on each phase being tested. Record resistance reading at 30 sec and at 1 min after test voltage is applied. Divide 1 minute reading by 30 second reading to obtain dielectric absorption ratio (DAR). DAR shall be 1.25 or greater for phase to pass test.
4. If phases have DAR of 1.25 or greater, attach tag to motor and mark tag "Insulation Resistance Test OK" and sign.
5. If phases have DAR of less than 1.25, attach tag to motor and mark tag “Insulation Resistance Test Failed” and sign. Provide new motor and retest. Notify Engineer of failure and actions taken to correct.
6. Connect equipment removed in Item 1 above.

C. Before energizing motor, record motor's nameplate current on record drawing line diagrams. Size motor starter overload heaters with starter manufacturer's recommendation for given motor nameplate current, service factor, and power factor correcting capacitors, if provided.

D. Check rotation of motor before connecting to driven equipment; before couplings are bolted or belts installed. Before motor is started to check rotation, determine that motor is lubricated. When rotation is correct, mark insulation resistance test tag "Rotation OK". Sign or initial test tag by person who checked motor rotation.

E. Supplier or manufacturer shall direct services to system and equipment operation, maintenance, troubleshooting, and equipment and system-related areas other than wastewater treatment process. See Section 01 61 00.

F. In addition to the services specified above, provide manufacturer’s services as required to successfully complete systems demonstration as specified in Section 01 79 10.

END OF SECTION

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SECTION 26 08 00
ELECTRICAL SYSTEM DEMONSTRATION

PART 1- GENERAL

1.01 SUMMARY

A. Demonstrate proper operation of electrical systems and equipment in presence of Engineer.

1.02 SUBMITTALS

A. Demonstration log.

B. Submit in accordance with Section 01 33 00.

PART 2- PRODUCTS

(Not Used)

PART 3- EXECUTION

3.01 PERFORMANCE

A. Demonstrations:

1. Each piece of equipment.
2. Each integrated system.

B. Demonstration Log:

1. Keep log of individual demonstrations.
2. Data:

a. Date and time of demonstration.
b. Owner's representative.
c. Equipment or system demonstrated.
d. Result of demonstration.

1) Success or fail.
2) If failure, description of failure.
3) Corrective action taken.
4) Redemonstration result.

END OF SECTION

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SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1- GENERAL

1.01 SUBMITTALS

A. Product Data: Include data on features, components, ratings, and performance for each type of transformer specified. Include dimensioned plans, sections, and elevation views. Show minimum clearances and installed devices and features.

B. Shop Drawings:

1. Wiring Diagrams: Detail wiring and identify terminals for tap changing and connecting field-installed wiring.

C. Test Results:

1. Reports on transformer tests.

D. Submit in accordance with Section 01 33 00.

1.02 QUALITY ASSURANCE

A. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

B. Regulatory Requirements:

1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.

C. Comply with Institute of Electrical and Electronics Engineers (IEEE) C2.

D. Comply with NFPA 70.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within enclosure of each ventilated-type unit throughout periods during which equipment is not energized and is not in space that is continuously under normal control of temperature and humidity.

PART 2- PRODUCTS

2.01 MANUFACTURERS

A. Square D.

B. Cutler-Hammer

2.02 TRANSFORMERS, GENERAL

A. Factory-assembled and -tested, air-cooled units of types specified, designed for 60 Hz service.

B. Cores: Grain-oriented, nonaging silicon steel.

C. Coils: Continuous copper windings without splices, except for taps.

D. Internal Coil Connections: Brazed or pressure type.

E. Enclosure: Class complies with National Electrical Manufacturers Association (NEMA) 250 for environment in which installed.

2.03 GENERAL-PURPOSE DISTRIBUTION AND POWER TRANSFORMERS

A. Comply with NEMA ST 20 and list and label as complying with UL 1561.

B. Efficiency: Efficiency equal to or greater than that stated in Department of Energy (DOE) 10 CFR Part 431 (2016), for that type and rating of transformer.

C. Cores: 1 leg per phase.

D. Windings: One coil per phase in primary and secondary.

E. Enclosure: Indoor, ventilated.

F. Insulation Class: 220°C class 115 degrees Celsius maximum rise above 40°C for transformers 15 Kilovoltamps (kVA) or smaller; 220°C class 80°C maximum rise above 40°C for transformers larger than 15 kVA.

G. Taps: For transformers 3 kVA and larger, full-capacity taps in high-voltage windings are as follows:

1. Taps, 3 through 15 kVA: Two 5% taps below rated high voltage.

H. Wall-Mounting Brackets: Manufacturer's standard brackets for transformers up to 75 kVA.

2.04 CONTROL AND SIGNAL TRANSFORMERS

A. Units comply with NEMA ST 1 and are listed and labeled as complying with UL 506.

B. Ratings: Continuous duty. If rating is not indicated, provide capacity exceeding peak load by 50% minimum.

C. Self-cooled, 2 windings.

2.05 FINISHES

A. Indoor Units: Manufacturer's standard paint over corrosion-resistant pretreatment and primer.

B. Outdoor Units: Comply with ANSI C57.12.28.

2.06 SOURCE QUALITY CONTROL

A. Factory Tests: Design and routine tests comply with referenced standards.

PART 3- EXECUTION

3.01 INSTALLATION

A. Comply with safety requirements of IEEE C2.

B. Arrange equipment to provide adequate spacing for access and for circulation of cooling air.

C. Identify transformers and install warning signs according to Section 26 05 53.

D. 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.

3.02 GROUNDING

A. Comply with NFPA 70 requirements separately derived systems for connecting to grounding electrodes and for bonding to metallic piping near transformer.

B. Comply with Section 26 05 26 for materials and installation requirements.

3.03 FIELD QUALITY CONTROL

A. Provide testing as specified in Section 26 01 26.

3.04 CLEANING

A. On completion of installation, inspect components. Remove paint splatters and other spots, dirt, and debris. Repair scratches and mars on finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

3.05 ADJUSTING

A. After installing and cleaning, touch up scratches and mars on finish to match original finish.

B. Adjust transformer taps and connections to provide optimum voltage conditions at utilization equipment throughout normal operating cycle of facility. Record primary and secondary voltages and tap settings or connections and submit with test results.

END OF SECTION

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SECTION 26 24 16
PANELBOARDS

PART 1- GENERAL

1.01 SUMMARY

A. Section Includes:

1. Lighting and power panelboards and associated auxiliary equipment rated 600 Volts and less.

1.02 SUBMITTALS

A. Product Data: For each type of panelboard, accessory item, and component specified.

B. Shop Drawings: For panelboards. Include dimensioned plans, sections, and elevations. Show tabulations of installed devices, major features, and voltage rating. Include following:

1. Enclosure type with details for types other than National Electrical Manufacturers Association (NEMA) 250, Type 1.
2. Bus configuration and current ratings.
3. Short-circuit current rating of panelboard.
4. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.

C. Test Results:

1. Indicate and interpret field test results for compliance with performance requirements.

D. Operation and Maintenance Manuals:

1. Instruction books and leaflets.
2. Recommended renewal parts list.
3. Drawings and information.
4. Submit in accordance with Section 01 78 23.

E. Submit in accordance with Section 01 33 00.

1.03 QUALITY ASSURANCE

A. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

B. Regulatory Requirements:

1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.

C. Comply with National Electrical Manufacturers Association (NEMA) PB 1.

PART 2- PRODUCTS

2.01 MANUFACTURERS

A. Square D Co.

B. Cutler-Hammer/Eaton

2.02 PANELBOARD FABRICATION

A. Enclosures: Flush- or surface-mounted cabinets as indicated. NEMA PB 1, Type 1, unless otherwise indicated to meet environmental conditions at installed location.

1. Outdoor Locations: NEMA 250, Type 3R/12.
2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
3. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

B. Front: Secured to box with concealed trim clamps, unless otherwise indicated. Front for surface-mounted panelboards shall be same dimensions as box. Fronts for flush panelboards shall overlap box, unless otherwise indicated.

C. Directory Frame: Metal, mounted inside each panelboard door.

D. Bus: Hard drawn tin plated copper of 98% conductivity.

E. Main and Neutral Lugs: Compression type.

F. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors. Bonded to box.

G. Service Equipment Approval: Listed for use as service equipment for panelboards with main service disconnect.

H. Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances, for overcurrent protective device ampere ratings indicated for future installation of devices.

I. Special Features: Include following features for panelboards as indicated:

1. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box.

J. Extra Gutter Space: Dimensions and arrangement as indicated.

1. Subfeed: Overcurrent protective device or lug provision as indicated.

K. Feed-through Lugs: Sized to accommodate feeders indicated.

2.03 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

B. Doors: In panelboard front, with concealed hinges. Secure with flush catch and tumbler lock, keyed alike.

2.04 DISTRIBUTION PANELBOARDS

A. Branch-Circuit Breakers: Where overcurrent protective devices are indicated to be circuit breakers, use bolt-on circuit breakers, except circuit breakers 225-Amp frame size and greater may be plug-in type where individual positive-locking device requires mechanical release for removal.

2.05 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 1, handle lockable.

1. Characteristics: Frame size, trip rating, number of poles, and auxiliary devices as indicated and interrupting capacity rating to meet available fault current.
2. Application Listing: Appropriate for application, including Type SWD for switching fluorescent lighting loads, Type HACR for heating, air-conditioning, and refrigerating equipment and Class B GFCI for pipeline and vessel fixed electrical heating equipment unless otherwise indicated.
3. Circuit Breakers, 200 Amp and Larger: Trip units interchangeable within frame size.
4. Circuit Breakers, 400 Amp and Larger: Field-adjustable short-time and continuous current settings.
5. Current-Limiting Trips: Where indicated, let-through ratings less than NEMA FU 1, Class RK-5.
6. Current Limiters: Where indicated, integral fuse listed for circuit breaker.
7. Lugs: Mechanical lugs and power-distribution connectors for number, size, and material of conductors indicated.
8. Shunt Trip: Where indicated.
9. Series rated circuit breakers not acceptable.

2.06 SURGE PROTECTION DEVICES

A. Provide in accordance with Section 26 43 13.

PART 3- EXECUTION

3.01 INSTALLATION

A. Install panelboards and accessory items according to NEMA PB 1.1.

B. Mounting Heights: Top of trim 74 inch (1880 millimeter) above finished floor, unless otherwise indicated.

C. Mounting: Plumb and rigid without distortion of box. Mount flush panelboards uniformly flush with wall finish.

D. Circuit Directory: Type directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing.

E. Install filler plates in unused spaces.

F. Wiring in Panelboard Gutters: Arrange conductors into groups, and bundle and wrap with wire ties after completing load balancing.

3.02 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Section 26 05 53.

B. Panelboard Nameplates: Label each panelboard with engraved laminated-plastic or metal nameplates mounted with corrosion-resistant screws.

3.03 GROUNDING

A. Make equipment grounding connections for panelboards.

B. Provide ground continuity to main electrical ground bus.

3.04 CONNECTIONS

A. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A.

3.05 FIELD QUALITY CONTROL

A. Make insulation-resistance tests of each panelboard bus, component, and connecting supply, feeder, and control circuits.

B. Make continuity tests of each circuit.

C. Visual and Mechanical Inspection.

1. Check circuit breaker for proper mounting and compare nameplate data to drawings and specifications.
2. Operate circuit breaker to ensure smooth operations.
3. Inspect case for cracks or other defects.

D. Balancing Loads: After Substantial Completion, conduct load-balancing measurements and make circuit changes as follows:

1. Perform measurements during period of normal working load as advised by Owner.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of facility. Make special arrangements with Owner to avoid disrupting critical 24 hr services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. Recheck loads after circuit changes during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20% between phase loads, within panelboard, is not acceptable. Rebalance and recheck as required to meet this minimum requirement.

3.06 ADJUSTING

A. Set field-adjustable pick-up and time-sensitivity ranges in accordance with Section 26 05 73.

3.07 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

END OF SECTION

SECTION 26 24 19
MOTOR-CONTROL CENTERS

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Motor-control centers for use on ac circuits rated 600 Volts and less.

1.02 SUBMITTALS

A. Product Data:

1. Include dimensions, ratings, and data on features and components.

B. Shop Drawings: For each motor-control center specified in this Section. Include dimensioned plans, elevations, and component lists. Show ratings, including short-time and short-circuit ratings, and horizontal and vertical bus ampacities.

1. Schedule of features, characteristics, ratings, and factory settings of individual motor-control center units.
2. Wiring Diagrams: Interconnecting wiring diagrams pertinent to class and type specified for motor-control center. Schematic diagram of each type of controller unit indicated.

C. Motor Control Center Layout

1. Motor control center submitted shall include future spaces matching or exceeding the future spaces shown on drawings. Future spaces shall be grouped together as shown on drawings. If future spaces are shown as groups larger than 12 inch vertically, it is not acceptable to replace with multiple 6 inch or 12 inch spaces throughout motor control center. Provide additional motor control center section(s) as required to match or exceed total future vertical spaces as shown on drawings.
2. Motor control center layout submitted shall match as close as possible the motor control center layout shown on the drawings. Identical equipment and motors shown grouped together shall be grouped together with the tag numbers ascending from top to bottom or left to right.

D. Test Results:

1. Certified reports of field tests and observations.

E. Operation and Maintenance Data (O&M):

1. Maintenance data for Motor Control Center (MCC).
2. Submit in accordance with Section 01 78 23.

F. Miscellaneous:

1. 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.

G. Submit in accordance with Section 01 33 00.

H. Approval of equipment specified in this section is contingent upon approval of coordination study specified in Section 26 05 73.

1.03 QUALITY ASSURANCE

A. Source Limitations: Obtain similar motor-control devices through one source from single manufacturer.

B. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in OSHA Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

C. Regulatory Requirements:

1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for motor-control centers, including clearances between motor-control centers and adjacent surfaces and items, and are based on types and models indicated. Other manufacturers' motor-control centers with equal performance characteristics and complying with indicated maximum dimensions may be considered.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits of lengths that can be moved past obstructions in delivery path (double doors 72”W x 80”H).

B. Store so condensation will not occur on or in motor-control centers. Provide temporary heaters as required to prevent condensation.

C. Handle motor-control centers according to NEMA ICS 2.3. Use factory-installed lifting devices.

1.05 COORDINATION

A. Coordinate features of controllers and accessory devices with pilot devices and control circuits to which they connect.

B. Coordinate features, accessories, and functions of each motor controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.06 EXTRA MATERIALS

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

1. Spare Fuse and Indicating Lamps: Furnish 1 spare for every 5 installed units, but not less than 1 set of 3 of each kind.

PART 2– PRODUCTS

2.01 MANUFACTURERS

A. Square D Model 6

B. G.E./ABB

2.02 COORDINATION STUDY

A. Where coordination study specified in Section 26 05 73 recommends changes in types, classes, features or ratings of equipment or devices from those indicated, make written request for instruction. Obtain instructions from Engineer before ordering equipment or devices recommended to be changed.

2.03 MOTOR-CONTROL CENTERS

A. Wiring: NEMA ICS 3, Class I, Type B. Factory wiring shall be labeled at each end with markers which correspond to the approved shop drawing wiring diagrams.

B. Enclosures: Surface-mounted cabinets as indicated. NEMA 250, Type 1 gasketed, unless otherwise indicated to meet environmental conditions at installed location.

1. Compartments: Modular; individual doors have concealed hinges and quick-captive screw fasteners. Interlocks on combination controller units require disconnect means in off position before door can be opened or closed, except by consciously operating permissive release device.
2. Interchangeability: Compartments are constructed to remove units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in control center. Units requiring same size compartment are interchangeable, and compartments are constructed to permit ready rearrangement of units, such as replacing 3 single units with unit requiring 3 spaces, without cutting or welding.
3. Wiring Spaces: Each vertical section of structure with horizontal and vertical wiring has spaces for wiring to each unit compartment in each section, with supports holding wiring in place.

C. Short-Circuit Current Rating for Each Section: Equal to or greater than indicated available fault current in symmetrical amperes at motor-control center location.

2.04 BUSES

A. Material: Tin Plated copper.

B. Ampacity Ratings:

1. As indicated for horizontal buses.
2. 300 amp mininum for vertical main buses or larger as required for installed units.

C. Neutral Buses: Full size.

D. Equipment Ground Bus: Noninsulated, horizontal copper bus 2 by 1/4 inch (50 by 6 millimeter), minimum.

E. Horizontal Bus Arrangement: Main phase, neutral and ground buses extended with same capacity entire length of motor-control center, with provision for future extension at both ends by bolt holes and captive bus splice sections.

F. Short-Circuit Withstand Rating: Same as short-circuit current rating of section.

2.05 FUNCTIONAL FEATURES

A. Description: Modular arrangement of motor controllers, control devices, overcurrent protective devices, transformers, panelboards, instruments, indicating panels, blank panels, and other items mounted in compartments of motor-control center as indicated.

B. Motor-Controller Units: Combination controller units of types and with features, ratings, and circuit assignments indicated.

1. Units with full-voltage, across-the-line, magnetic controllers up to and including Size 3 are installed on drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
2. Units have short-circuit current ratings equal to or greater than short-circuit current rating of motor-control center section.
3. Units in motor-control centers with Type B wiring are equipped with pull-apart terminal strips or drawout terminal boards for external control connections.

C. Overcurrent Protective Devices: Types of devices with features, ratings, and circuit assignments indicated. Individual feeder-tap units through 225-Amp rating shall be installed on drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.

D. Surge Protective Devices: Connected to motor-control center bus.

E. Spaces and Blank Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of drawout units.

F. Spare Units: Type, sizes, and ratings as indicated, and installed in compartments indicated "spare."

G. Kirk Key Interlock System: As shown on drawings.

2.06 MAGNETIC MOTOR CONTROLLERS

A. Description: NEMA ICS 2, Class A, full voltage, non-reversing, across-the-line, unless otherwise indicated.

B. Control Circuit: 120 Volts; obtained from integral control power transformer, unless otherwise indicated. Include control power transformer with adequate capacity to operate connected pilot, indicating and control devices, plus 100% spare capacity.

C. Combination Controller: Factory-assembled combination controller and disconnect switch with or without overcurrent protection as indicated.

1. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses indicated. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by Nationally Recognized Testing Laboratory.
2. Nonfusible Disconnect: NEMA KS 1, heavy-duty, nonfusible switch.
3. Circuit-Breaker Disconnect: NEMA AB 1, motor-circuit protector with field-adjustable short-circuit trip coordinated with motor locked-rotor amperes.

D. Overload Relay:

1. Electronic solid state type with inverse-time-current characteristic, phase loss and phase unbalance protection with normally closed overload trip contact for monitoring.
2. Provide NEMA Class 20 heaters or sensors in each phase matched to nameplate full load current of specific motor to which connected with appropriate adjustment for duty cycle.
3. Enhanced Protection Overload Relay: Provide overload relays with NEMA Class 10 or better tripping characteristics for submersible equipment or where indicated. Select to protect motor against voltage unbalance and single phasing.

E. When power factor correction capacitors are indicated provide termination lugs on line side of overload relays.

F. Time Delay Restart Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection.

1. Provide in starter enclosure for Size 2 and larger starters.
2. Delay initial motor start.
3. Delay motor restart due to starter dropout caused by undervoltage or starter coil circuit interruption for maintained control circuits.
4. Field adjustable on delay from 0.15 to 30.0 seconds factory set at 10.0 seconds.
5. Connect control relay in motor starter coil circuit.
6. Coordinate control relay section with motor starter to cause motor starter to drop out at voltage slightly higher than dropout voltage of starter and have dropout time slightly faster than motor starter to ensure if motor starter drops out, relay will drop out.

2.07 FEEDER OVERCURRENT PROTECTION

A. Molded-Case Circuit Breaker: NEMA AB 1, handle lockable.

1. Characteristics: Frame size, trip rating, number of poles, and auxiliary devices as indicated and interrupting capacity rating to meet available fault current.
2. Application Listing: Appropriate for application, including Type HACR for heating, air-conditioning, and refrigeration equipment.
3. Circuit Breakers, 200 Amp and Larger: Trip units interchangeable within frame size.
4. Circuit Breakers, 400 Amp and Larger: Field-adjustable, short-time, long-time, instantaneous, and continuous-current settings.
5. Current-Limiting Trips: Where indicated, let-through ratings less than NEMA FU 1, Class RK-5.
6. Lugs: Mechanical lugs and power-distribution connectors for number, size, and material of conductors indicated.
7. Shunt Trip: Where indicated or required for ground fault protection trip.
8. Series rated circuit breakers not acceptable.

2.08 ACCESSORIES

A. Factory install in controller enclosure, unless otherwise indicated.

1. “Run” and “Stopped” LED Pilot Lights, push-to-test: NEMA ICS 2, heavy-duty type.

a. “Run” – Red.
b. “Stopped” – Green.

B. Furnish following devices when indicated on Drawings.

1. Push-Button Stations and Selector Switches: NEMA ICS 2, heavy-duty type.
2. Stop and Lockout Push-Button Station: Momentary-break push-button station with factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
3. Control Relays: Auxiliary and adjustable time-delay relays.
4. Elapsed Time Meters: Heavy duty with digital readout in hours.
5. Multifunction Digital-Metering Monitor: UL-listed or -recognized, microprocessor-based unit suitable for three- or four-wire systems and with following features:

a. Phase Currents, Each Phase: Plus or minus 1%.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1%.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1%.

d. Three-Phase Real Power: Plus or minus 2%.
e. Three-Phase Reactive Power: Plus or minus 2%.
f. Power Factor: Plus or minus 2%.
g. Frequency: Plus or minus 0.5%.
h. Provide with Modbus TCP/IP communications.

CATEGORY SERVICE ENTRANCE	EXTERNAL EXPOSURE
C1	LOW
C2	MEDIUM
C3	HIGH
CATEGORY DISTRIBUTION LEVEL	EXTERNAL EXPOSURE
B1	LOW
B2	MEDIUM
B3	HIGH

C. Surge Protective Devices:

1. IEEE C62.41, selected to meet requirements for category C3.
2. Protection modes and UL 1449 clamping voltages coordinated with circuit system and circuit voltage.
3. Factory mounted with UL listed and labeled mounting device.
4. 200 kiloamp (kA) per phase surge current capacity minimum.
5. Flange mounted disconnect switch.
6. Door mounted diagnostic lights.
7. Audible alarm, with silencing switch, to indicate when protection has failed.
8. Replaceable modular design.
9. Mounted next to main incoming device.
10. One Form C contact to indicate suppressor is operational.

PART 3- EXECUTION

3.01 APPLICATIONS

A. Select features of each motor controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions.

B. Select horsepower rating of controllers to suit motor controlled.

C. Push-Button Stations: In covers of magnetic controllers for manually started motors where indicated, start contact connected in parallel with sealing auxiliary contact for low-voltage protection.

D. Hand-Off-Automatic Selector Switches: Where Indicated.

E. LED Pilot Lights: Push to test “Run” and “Stopped” pilot lights.

3.02 INSTALLATION

A. Install motor-control centers according to NEMA ICS 2.3 and manufacturer's written instructions.

B. Anchor each motor-control center assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by tack welding or bolting. Level and grout sills flush with motor-control center mounting surface.

C. Install motor-control centers on concrete housekeeping bases.

D. Fuses: Install fuses in each fusible switch.

3.03 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs according to Section 26 05 53.

3.04 CONTROL WIRING INSTALLATION

A. Install wiring between motor-control devices according to Section 26 05 19.
B. Bundle, train, and support wiring in enclosures.
C. Connect hand-off-automatic switch and other automatic control devices according to indicated wiring diagram or one that is manufacturer approved, where available.

1. Connect selector switches to bypass only manual and automatic control devices that have no safety functions when switch is in hand position.
2. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.05 CONNECTIONS

A. Tighten motor-control center bus joint, electrical connector, and terminal bolts according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A.

3.06 COORDINATION STUDY

A. Where coordination study specified in Section 26 05 73 recommends changes in types, classes, features of ratings of equipment or devices from those indicated, make written request for instructions. Obtain instructions from Engineer before ordering equipment or devices recommended to be changed.

3.07 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:

1. Supplier's or manufacturer's representative for equipment specified herein shall be present at jobsite or classroom designated by Owner for minimum workdays indicated, travel time excluded, for assistance during plant construction, plant startup, and training of Owner's personnel for plant operation. Include:

a. 1 workday for Installation Services.
b. 1/2 workday for Instructional Services.

2. Supplier or manufacturer shall direct services to system and equipment operation, maintenance, troubleshooting, and equipment and system-related areas other than wastewater treatment process. See Section 01 61 00.
3. In addition to the services specified above, provide manufacturer’s services as required to successfully complete systems demonstration as specified in Section 01 79 10.

B. Test and inspect in accordance with Section 26 01 26.

3.08 ADJUSTMENTS

A. Set field-adjustable pick-up and time-sensitivity ranges in accordance with Section 26 05 73.

3.09 CLEANING

A. Inspect interior and exterior of motor-control centers. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally, using methods and materials recommended by manufacturer.

END OF SECTION

SECTION 26 27 26
WIRING DEVICES

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Receptacles, connectors, switches, and finish plates.

1.02 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

1.03 SUBMITTALS

A. Submittals are not required if one of named manufacturers is furnished. If named manufacturer is not furnished submit Product Data and Samples.

B. Product Data:

1. For each product specified that is not one of the named manufacturers.

C. Samples:

1. For devices and device plates for color selection and evaluation of technical features.

D. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in OSHA Regulation 1910.7.
2. Term "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

B. Regulatory Requirements:

1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.

C. Comply with National Electrical Manufacturers Association (NEMA) WD 1.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Wiring Devices:

1. Bryant Electric, Inc.
2. GE Company; GE Wiring Devices.
3. Hubbell, Inc.; Wiring Devices Div.
4. Killark Electric Manufacturing Co.
5. Pass & Seymour/Legrand; Wiring Devices Div.
6. Pyle-National, Inc.; an Amphenol Co.

B. Wiring Devices for Hazardous (Classified) Locations:

1. Crouse-Hinds Electrical Co.; Distribution Equipment Div.
2. Killark Electric Manufacturing Co.
3. Pyle-National, Inc.; an Amphenol Co.

C. Multioutlet Assemblies:

1. Airey-Thompson Co.
2. Wiremold.

D. Poke through, Floor Service Outlets and Telephone/Power Poles:

1. Hubbell, Inc.; Wiring Devices Div.
2. Pass & Seymour/Legrand; Wiring Devices Div.
3. Square D Co.
4. Wiremold.

2.02 RECEPTACLES

A. Straight Blade and Locking Receptacles: Heavy Duty specification grade.

B. GFCI Receptacles: Termination type, with integral NEMA WD 6, Configuration 5-20R duplex receptacle. Design units for installation in 2-3/4 inch (70 millimeter) deep outlet box without an adapter.

C. Industrial Heavy Duty Receptacle: Comply with International Electrotechnical Commission (IEC) 309-1 and 309-2.

D. Hazardous (Classified) Location Receptacles: Comply with NEMA FB 11.

1. Appleton Cat. No. EFS B175-2023M, Crouse-Hinds Cat. No. ENR 21201 with NEMA 5-20R.
2. Plugs: Match receptables. Furnish 1 plug for each receptacle installed.

E. Color: White unless otherwise indicated or required by Code.

2.03 SWITCHES

A. Snap Switches: Heavy duty, quiet type.

B. Snap Switches in Hazardous (Classified) Locations:

1. Appleton EFS series, Crouse-Hinds EDS series.
2. Comply with UL Standard 894.

2.04 WALL PLATES

A. Single and combination types match corresponding wiring devices.

1. Plate Securing Screws: Metal with head color to match plate finish.
2. Finished Spaces: 0.04 inch (1 millimeter) thick, Type 302, satin finished stainless steel.
3. Unfinished Spaces: Galvanized steel.
4. Exterior and wet locations: Weatherproof plates and covers.
5. Exterior and wet locations: Weatherproof plates and covers suitable for wet locations while in use.

a. Hinged and gasketed cover/enclosure to maintain weather tight seal while the equipment is plugged into it. TayMac or equal.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Mounting height as follows unless otherwise shown on Drawings:

1. Switches: 48 inch above floor.
2. AC Receptacles and Telephone Outlets: 15 inch above floor or 6 inch above counters, counter back-splashes, and baseboard radiators in finished areas; 48 inch above floor in unfinished areas.

B. Install devices and assemblies plumb and secure.

C. Install wall plates when painting is complete.

D. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

E. Protect devices and assemblies during painting.

3.02 IDENTIFICATION

A. Comply with Section 26 05 53.

1. Switches: Where three or more switches are ganged, and elsewhere as indicated, identify each switch with approved legend engraved on wall plate.
2. Receptacles: Identify panelboard and circuit number from which served. Use machine printed, pressure sensitive, abrasion resistant label tape on face of plate and durable wire markers or tags within outlet boxes.

3.03 CONNECTIONS

A. Connect wiring device grounding terminal to branch circuit equipment grounding conductor.

B. Tighten electrical connectors and terminals according to manufacturers published torque-tightening values. If manufacturers torque values are not indicated, use those specified in UL 486A.

3.04 FIELD QUALITY CONTROL

A. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.

B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.

C. Replace damaged or defective components.

3.05 CLEANING

A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION

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SECTION 26 28 00
LOW-VOLTAGE CIRCUIT PROTECTION DEVICES

PART 1- GENERAL

1.01 SUMMARY

A. Section Includes:

1. Feeder and equipment disconnects.

1.02 SUBMITTALS

A. Shop Drawings:

1. Wiring diagrams detailing power and control wiring and differentiating clearly between manufacturer-installed wiring and field-installed wiring.

B. Operating and Maintenance Data (O&M):

1. Maintenance data for tripping devices.
2. Submit in accordance with Section 01 78 23.

C. Submit in accordance with Section 01 33 00.

1.03 QUALITY ASSURANCE

A. Items provided under this section shall be listed or labeled by UL or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in OSHA Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

B. Regulatory Requirements:

1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.

C. Single-Source Responsibility: Enclosed switches, fuses and circuit breakers shall be product of single manufacturer.

PART 2- PRODUCTS

2.01 MANUFACTURERS

A. Disconnect Switches:

1. Square D Co.
2. Cutler-Hammer.

2.02 ENCLOSED SWITCHES

A. Enclosed Nonfusible Switch: National Electrical Manufacturers Association (NEMA) KS 1, Type HD handle lockable with 2 padlocks.

B. Enclosed Fusible Switch, 800 Amps and Smaller: NEMA KS 1, Type HD, clips to accommodate specified fuses, enclosure consistent with environment where located, handle lockable with 2 padlocks, and interlocked with cover in closed position.

1. Minimum Fault Current Rating: 200,000 symmetrical rms amperes.

C. Enclosure: NEMA KS 1, Type 12, unless specified or required otherwise to meet environmental conditions of installed location.

1. Outdoor or Other Wet or Damp Indoor Locations: NEMA Type 4X 316 stainless steel
2. Hazardous Areas Indicated on Drawings: NEMA Type 7C.

D. Provide 120VAC rated dry contact for remote switch position indication.

PART 3- EXECUTION

3.01 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions to verify proper fuse locations, sizes, and characteristics.

B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install enclosed switches and circuit breakers in locations as indicated, according to manufacturer's written instructions.

B. Install enclosed switches and circuit breakers level and plumb.

C. Install wiring between enclosed switches and circuit breakers and control/indication devices.

D. Connect enclosed switches and circuit breakers and components to wiring system and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts according to equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.

3.03 IDENTIFICATION

A. Install typewritten labels on inside door of each fused switch to indicate fuse replacement information.

3.04 COORDINATION STUDY

A. Where coordination study recommends changes in types, classes, features or ratings of equipment or devices specified in Section 26 05 73 from those indicated, make written request for instructions. Obtain instructions from Engineer before ordering equipment or devices recommended to be changed.

3.05 CLEANING

A. Upon completion of installation, inspect over current protection devices. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

END OF SECTION

SECTION 26 29 23
VARIABLE FREQUENCY DRIVE EQUIPMENT

PART 1 – GENERAL

1.01 SUMMARY

A. Specifications for Variable Frequency Drive Equipment including Schedule 1 attached to this section.

B. Variable Frequency Drive Equipment for project shall be from the same manufacturer and shall be the same model and type.

1.02 REFERENCES

A. ANSI: American National Standards Institute

B. IEEE: Institute of Electrical and Electronics Engineers

C. UL: Underwriters Laboratory

1.03 SYSTEM DESCRIPTION

A. Unless otherwise specified, run signals shall be derived from motor starter normally open auxiliary contacts or from variable frequency drive.

B. References to “selector switch” refer to maintained contact type switch functions. Loss and return of control power to circuit does not change control mode or requirement as per switch position.

C. References to “push-button” refer to momentary contact type switch functions.

1.04 SUBMITTALS

A. Shop Drawings:

1. Panel fabrication and dimensions drawings.
2. Front of panel layout drawings.
3. Interior panel layout drawings.
4. Nameplate legend.
5. Component specification sheets.
6. Instruction manuals.
7. Parts list.
8. Recommended spare parts list.
9. Include Engineer’s tag number or description when available on each drawing, specification sheet, and manufacturer’s catalog cut in submittal for each component included in system.

B. Operation and Maintenance (O&M) Data:spade

1. Submit manufacturer’s standard O&M data indicating safety and periodic maintenance data.

C. Submit shop drawings and operation and maintenance data in accordance with the requirements of Section 01 33 00 and Section 01 78 23.

1.05 QUALITY ASSURANCE

A. Review equipment motor submittal for compatibility with drive system and to assure 20-year motor insulation design life and drive sizing.

B. Drive equipment shall conform to requirements of IEEE 519.

C. VFDs and options shall be UL listed as a complete assembly. The VFD package shall have a UL listed short circuit current rating (SCCR) of 65,000 amps and this rating shall be indicated on the UL data label

PART 2 – PRODUCTS

2.01 PULSE WIDTH MODULATED (PWM) VARIABLE FREQUENCY DRIVE (VFD)

A. Manufacturers.

1. Danfoss Model VLT AQUA Series FC 202 with MCB105 card.
2. ABB ACQ580 Series

B. General:

1. Ambient temperature 0 TO 40 ^{o}C.
2. Humidity: 5 to 95%, non-condensing.
3. cUL/UL approved or CSA certified and UL listed.
4. Factory wiring shall be labeled at each end with markers which correspond to the approved shop drawing wiring diagrams.

C. Input Power.

1. 460 Volts Alternating Current (VAC) (+/-10%).
2. 3-phase, 3-wire, any phase sequence.
3. 60 Hertz (+/-5%).
4. Capable of withstanding line voltage transients up to 3000 volts in accordance with ANSI 37.90.1 and ANSI C62.41.
5. Drive shall be constructed to limit line noise generated due to voltage distortion and line notch. Include as required to meet IEEE 519:

   a. Insulated Gate Bipolar Transistor (IGBT) switching.
   b. Direct Current (DC) Link Inductor.
   c. 3% Line Reactor. Coordinate with separate harmonic filter ahead of drive to assure that the operation of the drive is not impacted due to excessive impedance ahead of drive.

D. Output Power.

1. Match to motor.
2. 3-phase, 3-wire.
3. Sinusoidal wave, pulse width modulated wave form.
4. Maximum output: 460 VAC.
5. 6 to 60 Hertz, adjustable.
6. Frequency accuracy: +/- 1% of setting.
7. Rate full load output current in excess of motor nameplate current and increase motor current due to harmonics.
8. Output open and short circuit protection.

9. Power transistors shall be IGBT's with Peak Inverse Voltage (PIV) ratings of 1200 volts minimum.

E. Motor Performance.

1. 0.5% speed regulation in manual or automatic speed control mode.
2. 150% starting torque.
3. 100% rated torque from 60 Hertz to specified turndown over 10:1 speed range.

F. Drive features.

1. Selectable library of routines for 4-20 milliamps direct current (mAdc) follower circuitry to include output proportional to current, offset, slope, minimum clamp, and separate acceleration and deceleration adjustments.
2. Design circuit to accept 4-20 mAdc positive or negative signal, grounded or un-grounded.
3. Automatic restart on nuisance shutdown for up to 5 successive attempts.
4. Minimum Efficiency for constant torque applications.

    a. 100% rated speed and load – 95% or better.
    b. 70% rated speed and 100% load – 94% or better.
    c. 50% rated speed and 100% load – 93% or better.
    d. 30% rated speed and 100% load – 91% or better.
    e. 20% rated speed and 100% load – 87% or better.

5. Include PI (proportional, integral) control function integral to drive.
6. 110% overload capacity for 60 seconds.

G. Short Circuit and Drive Input Protection:

1. Instantaneous over-current trip shutdown set at 180% and 150% overload capacity for 60 seconds.
2. Under-voltage protection with automatic restart.
3. Input power circuit breaker with 65,000 amps interrupting capacity (AIC), labeled in accordance with UL Standard 489 with through the door operator.

    a. Provisions to lock in "OFF" position.
    b. Mechanical interlock to prevent opening cabinet door with disconnect in the "ON" position, or moving disconnect to the "ON" position with the door open.
    c. Auxiliary contact on main disconnect to isolate control power when control power fed from an external source.
    d. Barriers and warning signs on terminals that are energized with power disconnect "OFF".

H. Internal Protective Features:

1. Output phase sequence independent of input phase sequence.
2. Phase loss protection.
3. High or low sustained voltage shutdown.
4. 120 vac or 24 volts direct current (vdc) grounded control circuits.
5. Anti-regenerative circuit to protect inverter during deceleration.
6. Transistor over-current and over-temperature protection.
7. Electrically isolated low voltage logic.
8. DC bus fuse protection.
9. MOV (metal oxide varistor) surge protection.

I. Inverter Adjustments

1. Maximum Speed: 50 to 100% rated.
2. Minimum Speed: 6 to 70% rated.
3. Current limit: 10% to 150%.
4. Linear Acceleration: 3 to 300 seconds.
5. Linear Deceleration: 3 to 300 seconds.
6. Torque boost.
7. Maximum voltage level.
8. Electronic thermal overload: 10 to 100% of drive current.
9. Carrier frequency: 2.2 to 8.0 kilohertz (kHz) adjustable.
10. Up to three adjustable skip frequencies.
11. Selectable volts/Hertz patterns to include general purpose, variable torque, constant torque, constant horsepower, and programmable.
12. Fault Recovery: Auto Restart.
13. Loss of Power: Auto Restart.
14. I/O Assignments: Field Adjustable.

J. Inverter Diagnostic and Shutdown Protective Features:

1. External fault.
2. Low line voltage.
3. High line voltage.
4. Instantaneous current overload.
5. Internal over-temperature.
6. Over-current stall.
7. Over-voltage stall.
8. Ground fault.
9. Blown input fuse.
10. Control power supply failure.

K. Inverter construction:

1. Modular construction for ease of maintenance.
2. Easily accessible from front.
3. Construct boards of fire retardant materials in accordance with NEMA Grade FR4 specifications.

L. External Signals.

1. Provide communications module with Modbus TCP/IP protocol for data communications with plant supervisory control and data acquisition (SCADA) system.
2. Capable of accepting two-wire or three-wire start/stop control contacts in the automatic mode.
3. Accept 4-20 mAdc input speed reference with adjustable bias and gain.
4. Accept 0-10,000 ohm potentiometer input speed reference.
5. Accept external safety shutdown signals as specified or shown on drawings.
6. Provide dry contact for remote indication of drive run status.
7. Provide dry contact for remote indication of common equipment fail alarm.
8. Provide isolated 4-20 mAdc powered signal for remote indication of drive speed.

M. Operator interface:

1. Provide front of panel multifunction display/keypad, capable of controlling drive and setting drive parameters. Provide as a minimum with the following functions:

   a. Start

b. Stop
c. Reset
d. Increase/Decrease Speed Control
e. Manual or Remote Mode.

2. Display shall indicate following parameters:

a. Control mode – manual or automatic.
b. Output frequency.
c. Output voltage.
d. Output current.
e. Motor RPM.
f. Alarms and Faults.

3. Keypad functions shall include:

a. Menu driven.
b. Parameters stored in non-volatile memory.
c. Password or code protected.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Manufacturer's Field Services:

1. Supplier's or manufacturer's representative for equipment specified herein shall be present at job site or classroom designated by Owner for minimum workdays indicated, travel time excluded, to supervise final adjustment of system after installation is complete, system startup, and training of Owner's personnel for system operation. Include minimum of:

a. 1 workday for Installation Services.
b. 1/2 workday for Instructional Services.
c. 1/2 workday for Post Startup Services.

2. Supplier or manufacturer shall direct services to system and equipment operation, maintenance, troubleshooting, and equipment and system related areas. See Section 01 61 00.
3. In addition to the services specified above, provide manufacturer's services as required to successfully complete systems demonstration as specified in Section 01 79 00.

D. Installation and wiring of drive shall be by construction contractor.

SCHEDULE 1 TO SECTION 26 29 23

VARIABLE FREQUENCY DRIVES (VFD)

Enclosure Tag Number	Associated Equipment Description and Tag Number		Encl. Rating	Hp*	Equip. Spec.	Mode	Torque
VFD-PFIP-1	Influent Pump 1	PFIP-1	NEMA 1	60	432513	Volt/ Hertz	Variable
VFD-PFIP-2	Influent Pump 2	PFIP-2	NEMA 1	60	432513	Volt/ Hertz	Variable

VFD-PFIP-3	Influent Pump 3	PFIP-3	NEMA 1	60	432513	Volt/ Hertz	Variable
VFD-PFIP-4	Influent Pump 4	PFIP-4	NEMA 1	60	432513	Volt/ Hertz	Variable
VFD-PFTSP-1	Sludge Pump 1	PFTSP-1	NEMA 1	20	432357	Volt/ Hertz	Constant
VFD-PFTSP-2	Sludge Pump 2	PFTSP-2	NEMA 1	30	432357	Volt/ Hertz	Constant
VFD-SMP-1	Scum Pump 1	SMP-1	NEMA 1	5.2	432313	Volt/ Hertz	Variable
VFD-EF-105	Exhaust Fan 5	EF-105	NEMA 1	2	233423	Volt/ Hertz	Variable

* Verify Motor Horsepower and Full Load Current with Equipment Supplied.

END OF SECTION

SECTION 26 35 26
HARMONIC FILTERS

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Harmonic Filter System

1.02 SYSTEM DESCRIPTION

A. The Harmonic Filter System is a low pass harmonic filter used to nearly eliminate the input harmonic current reflected onto the power system.

1.03 SUBMITTALS

A. Product Data:

1. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model indicated.

B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

C. Operating and Maintenance Data (O&M):

1. Harmonic Filter System.
2. Submit O&M data in accordance with Section 01 78 23.

D. Warranties: Special warranties specified in this Section.

E. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

B. Regulatory Requirements:

1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.
2. Achieve compliance with both the current and voltage harmonic distortion limits as defined by IEEE-519 based on full load operating conditions.
3. UL listed per UL-508 or UL-508A.
4. Designed to meet the intent of BS G5/3, EN 61000-3-4, AS-2279 and IEEE-519.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. MTE Corporation, Matrix AP Harmonic Filter

B. Mirus Corporation, Lineator AUHF Harmonic Filter

C. TCI, Trans-Coil International, HSD Harmonic Filter

2.02 HARMONIC FILTER SYSTEM

A. Treat all of the characteristic low frequency harmonics generated by a 3-phase, 6-pulse rectifier load including the 5th, 7th, 11th, 13th, 17th, 19th, 23rd, 25th, etc.

B. Suppress 3-phase characteristic harmonics without tuning the filter or adjusting capacitors, inductors or other components.

C. Passive, series connected, low pass filter network consisting of inductors and capacitors with a series inductor to block source harmonics and prevent resonance. Insulated Gate Bipolar Transistor (IGBT) based active filters shall not be used. Stand alone harmonic traps shall not be used.

D. Accomplish harmonic attenuation without phase shifting loads against other harmonic sources.

E. Manufactured in the supplier's own manufacturing facility. Filters shall be fully tested prior to shipment.

F. Supplier shall provide evidence of relevant application experience upon request.

G. Suitable for use with one or more 6-pulse drives, whether the rectifier consists of diodes or Silicon-Controlled Rectifiers (SCR) and whether or not the drives have internal inductance such as line reactors or direct current (DC) link chokes. Extended warranty shall be optional.

H. The filter shall suppress characteristic harmonics to guaranteed levels provided that the power supply line voltage unbalance is between 0% and 1%. If the voltage unbalance is between 1% and 3%, per American National Standards Institute (ANSI) C84.1-1995, the total input harmonic distortion (THID) at any reduced load condition shall not exceed the full load THID by more than 50% (i.e.: if 5% THID at full load, then 7.5% THID at reduced load when voltage unbalance is >1%).

2.03 STANDARD FEATURES

A. Suitable for use on any three phase, 6-pulse SCR or diode rectified loads.

B. Suitable for use with either a single load or multiple non-linear loads.

C. Guaranteed harmonic distortion levels for all operating conditions from 50% load to 100% load.

D. For three phase, 6-pulse Variable Frequency Drive (VFD) system the full load input current harmonic distortion shall be limited to 8% THID.

E. True power factor - 0.98 lagging to 0.98 leading at the filter full load operating conditions and 0.95 leading at 80% load.

F. The harmonic filter shall not cause resonance with the power system.

G. The harmonic filter shall not attract harmonics from other loads which are connected upstream of the filter.

H. No adverse system interaction problems such as:

1. System resonance.
2. Overloading of filter by upstream harmonics.
3. Overloading of filter due to the addition of non-linear loads elsewhere on the system (upstream of the filter).

I. The filter shall not cause the dc bus voltage (of a voltage source inverter) to increase by more than 5% when operated from nominal supply voltage.

J. Use of the filter shall result in VFD input current waveform that is consistent with the input current waveform of a drive using a line reactor of 3% minimum impedance.

2.04 BASIC REQUIREMENTS

A. All internal filter wiring shall be copper.

B. Inductive component insulation systems: Class H (180°C).

C. Ambient temperature: -40 to +50°C (panel mounted construction).

D. Temperature rise: 115°C.

E. Full load efficiency: 98% minimum.

F. Enclosure: General purpose enclosure mounted separate from VFD.

2.05 FILTER ELECTRICAL REQUIREMENTS

A. 480 volts, 3 phase

PART 3 – EXECUTION

3.01 FIELD QUALITY CONTROL

A. The following inspections and test procedures shall be performed by factory trained field service personnel during startup.

1. Visual Inspection:

a. Inspect equipment for signs of damage.
b. Verify installation per drawings.
c. Verify ground conductors are properly sized and configured.

2. Mechanical Inspection:

a. Check all control wiring connections for tightness.
b. Check all power wiring connections for tightness.
c. Check all terminal screws, nuts, and/or spade lugs for tightness.

3. Supplier or manufacturer shall direct services to system and equipment operation, maintenance, troubleshooting, and equipment and system-related areas other than wastewater treatment process. See Section 01 61 00.
4. In addition to the services specified above, provide manufacturer's services as required to successfully complete systems demonstration as specified in Section 01 79 10.

3.02 FIELD TESTING AND STARTUP

A. Manufacturer shall provide field test personnel to initialize all equipment. A 3-phase harmonic analyzer shall be used to measure Total Demand Distortion (TDD) and Total Harmonic Distortion (THD) (Volt) levels to verify performance to specifications defined herein. Test reports shall be prepared for each point of test. Test reports shall be documented, signed, and dated. All tests shall be submitted to site manager.

B. Ground each Harmonic Filter enclosure.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A.

END OF SECTION

SECTION 26 41 00
FACILITY LIGHTNING PROTECTION

PART 1 – GENERAL

1.01 SUMMARY

A. This section covers furnishing the design of lightning protection systems and the furnishing and installation of lightning protection equipment.

B. Lightning protection systems shall be furnished, installed, and tested as specified. Lightning protection equipment shall meet the requirements specified herein.

C. Lightning protection systems shall consist of, but not be limited to, air terminals; main, bonding, and down conductors; ground terminals; and all required connectors and fittings required to complete the system.

D. The lightning protection system shall include the bonding of all roof-mounted mechanical equipment and other roof mounted metal objects.

1.02 GENERAL

A. Contractor shall furnish all installation drawings, tools, equipment, materials, and supplies and shall perform all labor and obtain all inspections to complete the work as specified, and in compliance with all codes, standards, and regulations.

B. Contractor shall provide coordination with other contractors and supervision of installation as needed during construction.

C. The design of the system shall include determination of the overall lightning hazard for the geographic location of the project and for the structures, the selection of Class I and/or Class II materials, the need of corrosion protection for the aluminum components used, and consideration of other pertinent factors. The design shall produce a zone of protection from lightning to prevent personal injury, structural damage, and equipment downtime.

D. Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the Drawings, Specifications, engineering data, instructions, and recommendations of UL unless exceptions are noted by Engineer.

E. The system shall be installed by an installer who has UL listing and subscribes to the UL Follow-Up Service.

1.03 GOVERNING STANDARDS

A. All system components furnished under this section shall be designed in accordance with ANSI/UL 96 - Lightning Protection Components. All lightning protection systems furnished under this section shall be designed, constructed, and tested in accordance with UL 96A – Installation Requirements for Lightning Protection Systems and ANSI/NFPA 780 – Standard for the Installation of Lightning Protection Systems.

B. Lightning protection systems shall be bonded to grounding electrode systems in accordance with the National Electrical Code.

1.04 SUBMITTALS

A. Complete certification of design calculations; assembly, and installation drawings; together with complete engineering data covering the materials used and the parts, devices, and accessories forming the system.

B. Submit in accordance with Section 01 33 00.

1.05 QUALITY ASSURANCE

A. Contractor shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions.

B. All equipment shall be designed, fabricated, and assembled in accordance with recognized and acceptable engineering and shop practice. Individual parts shall be manufactured to standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, unless required by tests.

C. The lightning protection system shall be inspected and tested after installation by conducting continuity and ground resistance tests as well as a visual inspection. Inspection results and test data shall be submitted in accordance with the Submittals Procedures section. Upon completion of the installation, Contractor shall apply for and deliver the UL Master Label Certificate of Inspection for each structure/building.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURES

A. The system components shall be manufactured by a company that has been specializing in the design and manufacture of UL listed lightning protection equipment for at least 5 years.

2.02 MATERIALS

A. All manufactured and fabricated components shall conform to NFPA 780 Class I or Class II as needed for the structures on which they will be installed. The system components shall be fabricated from the following metals:

1. Conductors – Aluminum.
2. Air Terminals – Aluminum.

B. All materials furnished for the lightning protection system shall bear the inspection label of UL.

PART 3 – EXECUTION

3.01 INSTALLATION

A. The lightning protection system shall be installed in a neat and inconspicuous manner so all components will blend in with the appearance of the building. All conductors shall be concealed or semi-concealed during construction using methods recommended in NFPA 780 and UL 96A.

B. Air terminals shall have base supports designed for the surface on which they are used and shall be securely anchored. All exposed metal eave troughs, roof vents, guy wires, antennas, and air handling equipment shall be bonded to the lightning protection system in such a way that two paths to ground are provided.

C. The lightning protection system shall be bonded to structure/building electrical ground rings wherever they are available.

3.02 SYSTEM RATINGS

A. Lightning protection system shall conform to the installation requirements of UL 96A and shall be qualified for a UL “Master Label” rating.

B. Installed lightning protection system shall be inspected and approved by a certified UL inspector.

C. Submit certificate of compliance with UL requirements for “Master Label” rating.

END OF SECTION

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SECTION 26 43 13
SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRIC POWER CIRCUITS

PART 1 – GENERAL

1.01 DESCRIPTION

A. Provide effective high energy transient voltage surge suppression, surge current diversion and high frequency noise attenuation in all electrical modes for equipment connected downstream from the facility's meter or load side of the main overcurrent device. Unit shall provide protection against both transient surges under 100 microseconds (μs) and temporary over voltages (TOV) and swells up to 2 minutes. Connect in parallel with the facility's wiring system.

B. Designed and manufactured in the USA by qualified manufacturer of suppression filter system equipment engaged in commercial design and manufacture of such products for minimum of five (5) years.

1.02 SUBMITTALS

A. Product Data:

1. Include rated capacities; shipping, installed and operating weights; furnished specialties; and accessories for each model indicated.

B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

C. Operation and Maintenance Data:

1. Surge Protective Devices (SPD).
2. Submit in accordance with Section 01 78 23.

D. Warrantees: Special warrantees specified in this Section.

E. Submit in accordance with Section 01 33 00.

1.03 ENVIRONMENTAL REQUIREMENTS

A. Storage Temperature. Storage temperature range shall be -40°C to +85°C (-40°F to +185°F).

B. Operating Temperature. Operating temperature range shall be -40°C +60°C (-40°F to +140 °F).

C. Relative Humidity: Operation shall be reliable in an environment with 5% to 95% non-condensing relative humidity.

D. Audible Noise: The unit shall not generate any audible noise.

E. Magnetic Field: No appreciable magnetic fields shall be generated.

1.04 QUALITY ASSURANCE

A. Systems shall be designed, manufactured, tested and installed in accordance with the following applicable documents and standards:

1. Underwriters Laboratories, Inc. (UL1449 4th edition and UL 1283 5th edition)
2. Canadian Standard Association (CSA)
3. National Electrical Manufacturers Association (NEMA LS1 - 1992)
4. American National Standards Institute / Institute of Electrical and Electronics Engineers ANSI/IEEE (C62.41 – 1991, C62.45 – 1992, and C62.34)
5. Military Standards (MIL-STD 220B)
6. National Electric Code (NEC)
7. National Fire Protection Association (NFPA 70 [NEC], 75 and 78)
8. Federal Information Processing Standards Publication 94 (FIPS PUB 94)
9. Underwriter's Laboratories 248-1

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Current Technology, Inc.
B. Approved Equal

2.02 SURGE PROTECTIVE DEVICE (SPD)

A. Surge suppressor shall have UL 1449 suppression ratings for each mode of protection, as follows:

1. 480/277 volt, 3 phase "WYE" – 1200 volts.
2. 120/208 volt, 3 phase "WYE" – 800 volts.
3. 480 volt 3 phase "Delta" – 1800 volts

B. Provide protection in all modes. Seven discrete modes for "WYE" systems, Line-to-Neutral (L-N), Line-to-Ground (L-G) and Neutral-to-Ground (N-G), and six modes for "Delta" systems, Line-to-Line (L-L) and Line-to-Ground (L-G). (See NEMA 2.2.7 & IEEE Std. 1100-1992).

C. Include a predetermined number of Selenium cells in parallel with arrays of non-linear voltage dependent metal oxide varistors (MOV) to protect against system voltage swells.

D. The Catastrophic Protection System shall provide TOV and voltage swell protection to the following:

1. TOV – should be capable of surviving and continue to protect critical loads against multiple TOV events (described as 200% nominal voltage by 8 milliseconds (ms).
2. Swell – should be capable of protection against swells up to 180% nominal for 0.7 ohms load for greater than 18,000 cycles.

E. MOVs tested per ANSI/IEEE C62.33-1982.

F. Minimum Single Pulse Surge Current Capacity per ANSI/IEEE C62041-1991's standard 8 X 20 μs current waveform, shall not be less than as follows:

Selenium Compact Select SPD (without disconnect) (SPD-100, SPD-101, SPD-122)

100,000 amps, L-N
100,000 amps, L-G min. amps per phase 200,000 (L-N plus L-G)
100,000 amps, N-G
100,000 amps, L-L

G. Test system for repetitive sequential ANSI/IEEE C62.41 Category C3 waveforms. Minimum repetitive strikes of 1.2 X 50 μs, 20 kilovolt (KV) open circuit voltage and 8 X 20 μs, 10 kiloampere (KA) short circuit current with no more than 10% degradation of clamping voltage at the specified surge current.

H. Provide an extended range noise tracking filter system between 50 kilohertz (kHz) and 100 megahertz (MHz) with a minimum insertion loss ratio of 50:1 or 34 db over the entire range per NEMA LS-1, 1992, Section 2.2.11. UL 1283 Listed as an Electromagnetic Interference Filter. (Standard insertion loss data obtained utilizing MIL-STD-220B 50 ohm insertion loss methodology).

I. Minimum continuous operating voltage (MCOV) of any component shall not be less than 115% of nominal operating voltage. MCOV shall be a tested value per section 37.7.3 of UL 1449 3rd Edition.

J. The primary suppression path shall be Line to Neutral.

K. All surge current devices shall incorporate low impedance plated busbars. No small gauge round wire, printed circuit boards, silicon avalanche diodes or plug-in connections are acceptable.

L. Each individual Selenium cell, MOV and capacitor shall be fused so that the failure of any component does not affect the operation or protection of the entire unit.

M. Provide in metal enclosure NEMA rated suitable for the installed location.

2.03 ACCESSORIES

A. SELENIUM SELECT SPD ON-LINE MONITORING

1. **MasterMIND Monitoring**. One set of status monitoring lights, that will provide visual indication of voltage present to the SPD. The lights shall also indicate when any value of less than 50% suppression protection is available from the SPD.

a. An audible alarm, a surge counter categorized into three industry recognizable categories, and two sets of Form C contacts for remote monitoring.

b. Monitoring system shall include a local character (M4E option) display to provide a time, date, magnitude, and duration stamp for when the following power quality events occur:

1) Sags (voltage < 90% of nominal)
2) Swells (voltage > 110% of nominal)
3) Surges (voltage > 130% of peak voltage)
4) Dropouts and Outages (power interruptions > 1 cycle)

c. System shall be capable of communicating remotely via Modbus-TCP over Ethernet and a web interface via Ethernet.

PART 3 - EXECUTION

3.01 SYSTEM TESTING

A. Factory test before shipment.

1. Testing shall include, but not be limited to production-line tests, quality assurance checks, MCOV, and benchmark clamping voltage tests.
2. A copy of the benchmark clamping tests for each individual SPD shall be included with each unit.

3.02 INSTALLATION

A. Selenium SPDs

1. SPDs shall be installed on load side of the main disconnects.

2. SPDs 150KA per mode and below shall have a dedicated circuit breaker disconnect at the connection point in the electrical distribution equipment. SPDs above 150KA per mode shall be connected directly to the equipment bus. Low impedance (HPI) cable shall be used to connect the SPD to the electrical distribution equipment. The total cable length between the SPD and the panelboards shall not exceed 20 feet.

3.03 SYSTEM WARRANTY

A. The SPD system manufacturer shall warranty the entire system against defective materials and workmanship for a period of twenty years for the Selenium Select SPDs.

END OF SECTION

SECTION 26 45 00
FIRE ALARM SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Manual stations.
2. Detectors.
3. Signal equipment.
4. Controls and devices.

1.02 DEFINITION

A. FACP: Fire Alarm Control Panel.

1.03 SYSTEM DESCRIPTION

A. Zoned, noncoded, addressable, microprocessor-based fire-detection and alarm system with manual and automatic alarm initiation. Zones as follows:
1. Main Pump II Building (Fire Alarm Control Panel in Electrical Room)
2. Primary Filtration Facility 1
3. Primary Filtration Facility 2 (Future)

B. Signal Transmission: Multiplex signal transmission dedicated to fire alarm service only.

C. Audible Alarm Indication: By sounding of horns and bells.

D. Visual Alarm Indication: By xenon-strobe-type units.

1.04 SUBMITTALS

A. Product Data:

1. Each type of system component specified including dimensioned plans and elevations showing minimum clearances and installed features and devices. Include list of materials and Nationally Recognized Testing Laboratory (NRTL) listing data.

B. Shop Drawings:

1. Show details of graphic annunciator.
2. Wiring diagrams from manufacturer differentiating clearly between factory- and field-installed wiring. Include diagrams for equipment and for system with terminals and interconnections identified. Make diagrams specific to this Project and distinguish between field and factory wiring.
3. Device Address List: Coordinate with final system programming.

C. Miscellaneous:

1. System operation description covering this specific Project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are unacceptable.

D. Test Reports:

1. Record of field tests of system.

E. Operating and Maintenance Data:

1. Operating instructions: Mount at Fire Alarm Control Panel (FACP).
2. Include data for each type of product, including features and operating sequences, both automatic and manual. Include recommendations for spare parts to be stocked at site. Provide names, addresses, and telephone numbers of service organizations that carry stock of repair parts for system to be furnished.

F. Submit in accordance with Section 01 33 00.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Engage experienced factory-authorized Installer to assist in performing work of this Section.

B. Single-Source Responsibility: Obtain fire alarm components from single source who assumes responsibility for compatibility of system components.

C. Compliance with Local Requirements: Comply with applicable building code, local ordinances, and regulations, and requirements of authorities having jurisdiction.

D. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code, Article 100.

E. Regulatory Requirements:

1. National Electrical Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70.
2. Comply with NFPA 72.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Simplex 4010ES

2.02 FUNCTIONAL DESCRIPTION OF SYSTEM

A. Include following system functions and operating features plus those additional functions and features required by authorities having jurisdiction:

1. Priority of Signals: Accomplish automatic response functions by first zone initiated. Alarm functions resulting from initiation by first zone are not altered by subsequent alarms. highest priority is alarm signal. Supervisory and trouble signals have second- and third-level priority. Higher-priority signals take precedence over signals of lower priority, even though lower-priority condition occurred first. Annunciate alarm signals regardless of priority or order received.

2. Noninterfering: Zone, power, wire, and supervise system so signal on 1 zone does not prevent receipt of signals from any other zone. All zones are manually resettable from FACP after initiating device or devices are restored to normal. Systems that require batteries or battery back-up for programming function are unacceptable.
3. Fire Alarm Control Panel Response: Manual or automatic operation of alarm-initiating or supervisory-operating device causes FACP to transmit appropriate signal including following:

    a. General alarm.
    b. Smoke or heat detector alarm.
    c. System trouble.

4. Transmission to Plant PLC: Automatically route alarm, supervisory, and trouble signals.
5. Silencing at FACP: Switches provide capability for acknowledgment of alarm, supervisory, trouble, and other specified signals at FACP; and capability to silence local audible signal and light light-emitting diode (LED). Subsequent zone alarms cause audible signal to sound again until silenced by switch operation. Restoring alarm, supervisory, and trouble conditions to normal extinguishes associated LED and causes audible signal to sound again until restoration is acknowledged by switch operation.
6. Loss of primary power sounds trouble signal at FACP. FACP indicates when fire alarm system is operating on alternate power supply.
7. Annunciation: Manual and automatic operation of alarm- and supervisory-initiating devices is annunciated both on FACP and on annunciator, indicating location and type of device.
8. FACP Alphanumeric Display: Displays plain-English-language descriptions and addresses of initiating devices, alarms, trouble signals, supervisory signals, monitoring actions, system and component status, and system commands.
9. General Alarm:

    a. Indicating general alarm condition at FACP and annunciator.
    b. Identifying device that is source of alarm (or its zone) at FACP and annunciator.
    c. Initiating audible and visible alarm signals throughout building.
    d. Stopping supply and return fans serving zone where alarm is initiated.
    e. Initiating transmission of alarm signal to remote PLC.

10. Manual station alarm operation initiates general alarm.
11. Smoke detection initiates general alarm.
12. Remote Detector Sensitivity Adjustment: Manipulation of controls at FACP causes selection of specific addressable smoke detectors for adjustment, display of their current status and sensitivity settings, and control of changes in those settings. Same controls can be used to program repetitive, scheduled, automated changes in sensitivity of specific detectors. Sensitivity adjustments and sensitivity adjustment schedule changes are recorded by system printer.
13. Permissible Signal Time Elapse: maximum permissible elapsed time between actuation of any fire alarm or fire-detection system alarm-initiating device and its indication at FACP is 2 seconds.
14. Circuit Supervision: Indicate circuit faults by both zone and trouble signal at FACP. Provide distinctive indicating audible tone and LED-indicating light. Maximum permissible elapsed time between occurrence of trouble condition and its indication at FACP is 200 seconds.

2.03 ADDRESSABLE DEVICES

A. Alarm-Initiating Devices: Classified as addressable devices according to NFPA 72.

1. Communication Transmitter and Receiver: Integral to device. Provides each device with unique identification and capability for status reporting to FACP.

2. External Addressable Interface Unit: May be used where specified devices are not manufactured and labeled with integral multiplex transmitter and receiver. Arrange to monitor status of each device individually.

2.04 MANUAL PULL STATIONS

A. Description: Double-action type, fabricated of metal or plastic, and finished in red with molded, raised-letter operating instructions of contrasting color.

1. Break-Glass Feature: Stations requiring breaking of glass panel are unacceptable. Stations requiring breaking of concealed glass rod are acceptable.
2. Station Reset: Key or wrench operated, double pole, double throw, switch rated for voltage and current at which it operates. Stations have screw terminals for connections.

2.05 SMOKE DETECTORS

A. General:

1. Factory Nameplate: Serial number and type identification.
2. Operating Voltage: 24 VDC, nominal.
3. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
4. Plug-in Arrangement: Detector and associated encapsulated electronic components are mounted in module that connects to fixed base with twist-locking plug connection. plug connection requires no springs for secure mounting and contact maintenance. Terminals in fixed base accept building wiring.
5. Integral Visual Indicating Light: Connect to indicate detector has operated.

2.06 ALARM-INDICATING DEVICES

A. Equip alarm-indicating devices for mounting as indicated. Provide terminal blocks for system connections.

B. Chimes, High-Level Output: Vibrating type, 81 dB, minimum-rated output.

C. Horns: Electric-vibrating-polarized type, operating on 24 VDC, with provision for housing operating mechanism behind grille. Horns produce sound-pressure level of 90 dB, measured 10 feet (3 meter) from source.

D. Visual Alarm Devices: Xenon strobe lights with clear or nominal white polycarbonate lens. Mount lenses on an aluminum faceplate. Word "FIRE" is engraved in minimum 1 inch (25 millimeter) high letters on lens.

1. Devices have minimum light output of 115 candela.

2. Strobe Leads: Factory connected to screw terminals.

3. Combination devices consist of factory-combined, audible and visual alarm units in single mounting assembly.

2.07 CENTRAL FIRE ALARM CONTROL PANEL (FACP)

A. Comply with UL 864.

B. Cabinet: Lockable steel enclosure. Arrange panel so operations required for testing or for normal care and maintenance of system are performed from front of enclosure. If more than single unit is required to form complete control panel, provide exactly matching modular unit enclosures. Accommodate components and allow ample gutter space for interconnection of panels and field wiring. Identify each enclosure by an engraved, red, laminated, phenolic-resin nameplate. Lettering on enclosure's nameplate shall not be less than 1 inch (25 millimeter) high. Identify individual components and modules within cabinets with permanent labels.

C. Systems: Alarm and supervisory systems are separate and independent in FACP. Alarm-initiating zone boards in FACP consist of plug-in cards. Construction requiring removal of field wiring for module replacement is unacceptable.

D. Control Modules: Types and capacities required to perform functions of fire alarm systems. Local, visible, and audible signals announce alarm, supervisory, and trouble conditions. Each type of audible alarm has different sound.

E. Zones: Provide for alarm and supervisory zones indicated.

F. Indicating Lights: Provide individual LED devices for each zone. An LED test switch for each FACP section illuminates LED devices on that section of control panel. Manual toggle test switches or push test-buttons do not require key to operate. Alarm and supervisory signals light red LED of associated zone. Trouble signals light an amber LED for associated zone.

G. Resetting: Provide necessary controls to prevent resetting of any alarm, supervisory, or trouble signal while alarm or trouble condition still exists.

H. Alphanumeric Display and System Controls: Arrange to provide basic interface between human operator at FACP and addressable system components, including annunciation and supervision. Display with minimum of 32 characters shows alarm, supervisory, and component status messages. Arrange keypad for use in entering and executing control commands.

2.08 EMERGENCY POWER SUPPLY

A. Components include sealed lead-acid battery, charger, and automatic transfer switch. Battery nominal life expectancy is 10 years, minimum.

B. Battery capacity is adequate to operate complete alarm system in normal or supervisory (nonalarm) mode for period of 24 hours. At end of this period, battery has sufficient capacity to operate system, including alarm-indicating devices in either alarm or supervisory mode, for period of 15 minutes minimum.

C. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Provide capacity for 150% of connected system load while maintaining batteries at full charge. In event batteries are fully discharged, charger recharges them completely within 4 hours. Charger output is supervised as part of system power supply supervision.

D. Integral Automatic Transfer Switch: Transfers load to battery without loss of signals or status indications when normal power fails.

2.09 WIRE

A. Wire: Solid-copper conductors with 600 V rated, 75 degrees Celsius, color-coded insulation.

1. Low-Voltage Circuits: No. 16 AWG, minimum.
2. Line-Voltage Circuits: No. 12 AWG, minimum.

PART 3 – EXECUTION

3.01 INSTALLATION, GENERAL

A. Install system according to NFPA 72.

B. Fire Alarm Power Supply Disconnect: Paint red and label "FIRE ALARM." Provide with lockable handle or cover.

3.02 EQUIPMENT INSTALLATION

A. Manual Pull Stations: Mount semiflush in recessed back boxes with operating handles 48 inch (1220 millimeter) above finished floor or lower as indicated.

B. Smoke Detectors: Install ceiling-mounted detectors not less than 4 inch (100 millimeter) from side wall to near edge. Install detectors located on wall at least 4 inch (100 millimeter), but not more than 12 inch (300 millimeter), below ceiling. For exposed solid-joist construction, mount detectors on bottom of joists. On smooth ceilings, install detectors not over 30 feet (9 meter) apart in any direction. Install detectors no closer than 60 inch (1520 millimeter) from air registers.

C. Audible Alarm-Indicating Devices: Install not less than 90 inch (2280 millimeter) above finished floor nor less than 6 inch (150 millimeter) below ceiling. Install bells and horns on flush-mounted back boxes with device-operating mechanism concealed behind grille or as indicated. Combine audible and visual alarms at same location into single unit.

D. Visual Alarm-Indicating Devices: Install 80 inch (2030 millimeter) above finished floor or 6 inch (150 millimeter) below ceiling whichever is lower.

E. Device Location-Indicating Lights: Locate in public space near device they monitor.

F. FACP: Surface mount with tops of cabinets not more than 72 inch (1830 millimeter) above finished floor.

3.03 WIRING INSTALLATION

A. Wiring Method: Install wiring in metal raceway according to Section 26 05 33.

B. Wiring within Enclosures: Install conductors parallel with or at right angles to sides and back of enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

C. Cable Taps: Use numbered terminal strips in junction, pull or outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

D. Color Coding: Color-code fire alarm conductors differently from normal building power wiring. Use 1 color code for alarm circuit wiring and different color code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visual alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

3.04 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals according to Section 26 05 53.

3.05 GROUNDING

A. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding.

B. Ground equipment and conductor and cable shields. For audio circuits, minimize, to greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.

3.06 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:

1. Supplier's or manufacturer's representative for equipment specified herein shall be present at jobsite or classroom designated by Owner for workdays indicated, travel time excluded, for assistance during equipment installation, equipment startup, and training of Owner's personnel for system operation. Include:

   a. 1 workday for Installation Services.
   b. 1 workday for Instructional Services.

2. Supplier or manufacturer shall direct services to system and equipment operation, maintenance, and troubleshooting. See Section 01 61 00.
3. Factory-authorized service representative shall inspect field-assembled components, installation, and connection of switchgear; and to pretest and adjust switchgear components. Report results in writing. See Section 01 79 10.

B. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting. Determine, through pretesting, conformance of system to requirements of Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.

C. Report of Pretesting: After pretesting is complete, provide letter certifying installation is complete and fully operable, including names and titles of witnesses to preliminary tests.

D. Final Test Notice: Provide 10 day minimum notice in writing when system is ready for final acceptance testing.

E. Minimum System Tests: Test system according to procedures outlined in NFPA 72. Minimum required tests are as follows:

1. Verify absence of unwanted voltages between circuit conductors and ground.
2. Test conductors for short circuits using insulation-testing device.
3. With each circuit pair, short circuit at far end of circuit and measure circuit resistance with ohmmeter. Record circuit resistance of each circuit on record drawings.
4. Verify that control unit is in normal condition as detailed in manufacturer's operation and maintenance manual.
5. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. 1 connection each should be opened at not less than 10% of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
6. Test each initiating and indicating device for alarm operation and proper response at control unit. Test smoke detectors with actual products of combustion.
7. Test Both Primary and Secondary Power: Verify by test that secondary power system is capable of operating system for period and in manner specified.

F. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by system test that total system meets Specifications and complies with applicable standards.

G. Report of Tests and Inspections: Provide written record of inspections, tests, and detailed test results in form of test log. Submit log upon satisfactory completion of tests.

H. Tag equipment, stations, and other components at which tests have been satisfactorily completed.

3.07 CLEANING AND ADJUSTING

A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marred finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer.

END OF SECTION

SECTION 26 51 00
INTERIOR LIGHTING

PART 1- GENERAL

1.01 SUMMARY

A. Section Includes:

1. Interior lighting fixtures
2. Lamps
3. Ballasts
4. Emergency lighting units
5. Accessories.

1.02 DEFINITIONS

A. Emergency Lighting Unit: Fixture with integral emergency battery-powered supply and means for controlling and charging battery. Also known as an emergency light set.

B. Fixture: Complete lighting unit, exit sign, or emergency lighting unit. Fixtures include lamps and parts required to distribute light, position and protect lamps, and connect lamps to power supply. Internal battery-powered exit signs and emergency lighting units also include battery and means for controlling and recharging battery. Emergency lighting units include ones with and without integral lamp heads.

C. Average Life: Time after which 50% fails and 50% survives under normal conditions.

1.03 SUBMITTALS

A. Product Data

1. Describe fixtures, lamps, ballasts, and emergency lighting units. Arrange Product Data for fixtures in order of fixture designation.
2. Include data on features and accessories and following:

a. Outline drawings indicating dimensions and principal features of fixtures.
b. Electrical Ratings and Photometric Data: Certified results of laboratory tests for fixtures and lamps.
c. Battery and charger data for emergency lighting units.

1.04 QUALITY ASSURANCE

A. Items provided under this section shall be listed or labeled by UL or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in OSHA Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code, Article 100.
3. Special Listing and Labeling: Provide fixtures for use in damp or wet locations, underwater, and recessed in combustible construction that are specifically listed and labeled for such use. Provide fixtures for use in hazardous (classified) locations that are listed and labeled for specific hazard.

B. Regulatory Requirements:

1. National Electrical Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70.

C. Fixtures for Hazardous Locations: Conform to UL 844. Provide units that have Factory Mutual Engineering and Research Corporation (FM) certification for indicated class and division of hazard.

D. Coordinate fixtures, mounting hardware, and trim with ceiling system and other items, including work of other trades, required to be mounted on ceiling or in ceiling space.

PART 2- PRODUCTS

2.01 FIXTURES AND FIXTURE COMPONENTS

A. Metal Parts: Free from burrs, sharp corners, and edges.

B. Sheet Metal Components: Steel, except as indicated. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.

D. Reflecting Surfaces: Minimum reflectance as follows, except as otherwise indicated:

1. White Surfaces: 85%.
2. Specular Surfaces: 83%.
3. Diffusing Specular Surfaces: 75%.
4. Laminated Silver Metallized Film: 90%.

E. Lenses, Diffusers, Covers, and Globes: 100% virgin acrylic plastic or water white, annealed crystal glass, except as otherwise indicated.

1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Lens Thickness: 0.125 inch (3 millimeter) minimum; except where greater thickness is indicated.

F. Fixture Support Components: Comply with Section 26 05 29.

1. Single-Stem Hangers: 1/2 inch (12 millimeter) steel tubing with swivel ball fitting and ceiling canopy. Finish same as fixture.
2. Twin-Stem Hangers: Two, 1/2 inch (12 millimeter) steel tubes with single canopy arranged to mount a single fixture. Finish same as fixture.
3. Rod Hangers: 3/16 inch (5 millimeter) minimum diameter, zinc-plated, threaded steel rod.
4. Hook Hanger: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

G. Light Emitting Diodes (LED):

1. Recessed Fixtures

a. LEDs rated for 50,000 hour life minimum.
b. Embedded controls shall allow fixture to communicate with other nLight enabled controls included but not limited to dimmers, switches, occupancy sensors, and photocontrols.
c. Lumen Management system (N80) provides onboard intelligence that actively manages the LED light source so that constant lumen output is maintained over the system life.
d. LED AccuDrive: driver delivers full-range dimming from 0-10V control signal.
e. CSA Certified.
f. Tested to LM80 standards.

g. UL listed driver.

2. Non-recessed Fixtures

a. LED rated for 100,000 hour life.
b. Embedded controls shall allow fixture to communicate with other nLight enabled controls included but not limited to dimmers, switches, occupancy sensors, and photocontrols
c. 0-10V dimming.
d. Damp rated.
e. CSA Certified.
f. UL listed driver.

H. Exit Signs: Conform to UL 924 and following:

1. Sign Colors: Conform to local code.
2. Minimum Height of Letters: Conform to local code.
3. Arrows: Include as indicated.

I. Self-Powered Exit Signs (Battery Type): Integral automatic high/low trickle charger in self-contained power pack.

1. Battery: Sealed, maintenance-free, nickel-cadmium type with special warranty.

J. Emergency Lighting Units: Conform to UL 924. Provide self-contained units with following features:

1. Battery: Sealed, maintenance-free, lead-acid type with minimum 10 year nominal life and special warranty.
2. Charger: Minimum 2-rate, fully automatic, solid-state type, with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when supply circuit voltage drops to 80% of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. Relay disconnects lamps and battery and automatically recharges and floats on trickle charger when normal voltage is restored.

2.02 FINISHES

A. Manufacturer's standard, except as otherwise indicated, applied over corrosion-resistant treatment or primer, free of streaks, runs, holidays, stains, blisters, and similar defects.

PART 3- EXECUTION

3.01 INSTALLATION

A. Set units plumb, square, and level with ceiling and walls, and secure according to manufacturer's written instructions and approved Shop Drawings. Support fixtures according to Section 26 05 29.

B. Support for Suspended Fixtures: Brace pendants and rods over 48 inch (1200 millimeter) long to limit swinging. Support stem-mounted, single-unit, suspended fluorescent fixtures with twin-stem hangers. For continuous rows, use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of chassis, including one at each end.

C. Lamping: Where specific lamp designations are not indicated, lamp units according to manufacturer's instructions.

3.02 CONNECTIONS

A. Ground lighting units. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A.

3.03 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replaced damaged fixtures and components.

1. Verify normal operation of each fixture after fixtures have been installed and circuits have been energized with normal power source.
2. Give advance notice of dates and times for field tests.
3. Provide instruments to make and record test results.
4. Interrupt electrical energy to demonstrate proper operation of emergency lighting installation. Include following information in tests of emergency lighting equipment:

    a. Replace or repair malfunctioning fixtures and components, then retest. Repeat procedure until all units operate properly.

B. Replace fixtures that show evidence of corrosion during Project warranty period.

3.04 ADJUSTING AND CLEANING

A. Clean fixtures after installation. Use methods and materials recommended by manufacturer.

B. Adjust aimable fixtures to provide required light intensities.

END OF SECTION

SECTION 26 56 00
EXTERIOR LIGHTING

PART 1– GENERAL

1.01 SUMMARY

A. Section Includes:

1. Exterior lighting fixtures.
2. Lamps.
3. Ballasts.
4. Pole standards.
5. Accessories.

1.02 DEFINITIONS

A. Fixture: Complete lighting device. Fixtures include lamp or lamps and parts required to distribute light, position and protect lamps, and connect lamps to power supply.

B. Lighting Unit: Fixture or assembly of fixtures with common support, including pole or bracket plus mounting and support accessories.

C. Luminaire: Fixture.

1.03 SUBMITTALS

A. Product Data:

1. Describe fixtures, lamps, ballasts, poles, and accessories. Arrange Product Data for fixtures in order of fixture designation. Include data on features, poles, accessories, finishes, and following:

a. Outline drawings indicating dimensions and principal features of fixtures and poles.
b. Electrical Ratings and Photometric Data: Certified results of laboratory tests for fixtures and lamps.

B. Operating and Maintenance Data (O&M):

1. Maintenance data for products to include operation and maintenance information.
2. Submit in accordance with Section 01 78 23.

C. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

A. Comply with American National Standards Institute (ANSI) C2.

B. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code, Article 100.

C. Regulatory Requirements:

1. National Electrical Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70.

D. Fixtures for Hazardous Locations: Conform to UL 844. Provide units that have Factory Mutual Engineering and Research Corporation (FM) certification for indicated class and division of hazard.

1.05 STORAGE AND HANDLING OF POLES

A. Store poles on decay-resistant treated skids at least 12 inch (300 millimeter) above grade and vegetation. Support pole to prevent distortion and arrange to provide free air circulation.

B. Metal Poles: Retain factory-applied pole wrappings until just before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

PART 2– PRODUCTS

2.01 FIXTURES AND FIXTURE COMPONENTS

A. Metal Parts: Free from burrs, sharp edges, and corners.

B. Sheet Metal Components: Corrosion-resistant aluminum, except as otherwise indicated. Form and support to prevent warping and sagging.

C. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed fixtures.

D. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position. Provide for door removal for cleaning or replacing lens. Arrange for door opening to disconnect ballast.

E. Exposed Hardware Material: Stainless steel.

F. Reflecting Surfaces: Minimum reflectances as follows, except as otherwise indicated:

1. White Surfaces: 85%
2. Specular Surfaces: 83%
3. Diffusing Specular Surfaces: 75%

G. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UltraViolet (UV) radiation.

H. Lenses and Refractors: Materials as indicated. Use heat- and aging-resistant, resilient gaskets to seal and cushion lens and refractor mounting in fixture doors.

I. Photoelectric Relays: Conform to UL 773.

1. Contact Relays: Single throw, arranged to fail in ON position and factory set to turn light unit on at 1.5 to 3 foot-candles (16 to 32 lumen per square meter (lux)) and off at 4.5 to 10 foot-candles (48 to 108 lux) with 15 sec minimum time delay.
2. Relay Mounting: In fixture housing.

J. Light Emitting Diodes (LED)

1. Driver shall be accessible for easy replacement.
2. Weatherproof fixture housing shall be sealed completely against moisture and environment

contaminants.
3. 5100K temperature, Color rendering index (CRI) greater than 70.
4. LED driver shall have power factor greater than 90% and THD less than 20%.
5. CSA Certified to US standards for 40°C ambient.

2.02 FIXTURE SUPPORT COMPONENTS

A. Pole-Mounted Fixtures: Conform to American Association of State Highway and Transportation Officials (AASHTO) LTS-3.

B. Wind-load strength of total support assembly, including pole, arms, appurtenances, base, and anchorage, is adequate to carry itself plus fixtures indicated at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of 100 Miles per Hour (mph) (160 Kilometers per Hour (km/h)) with gust factor of 1.3.

C. Arm, Bracket, and Tenon Mount Materials: Match poles' finish.

D. Mountings, Fastenings, and Appurtenances: Corrosion-resistant items compatible with support components. Use materials that will not cause galvanic action at contact points. Use mountings that correctly position luminaire to provide indicated light distribution.

E. Pole Shafts: Square, tapered.

F. Pole Bases: Embedded type with underground cable entry.

G. Aluminum Poles: American Society for Testing and Materials (ASTM) B429, 6063-T6 alloy. Provide access handhole in pole wall.

H. Metal Pole Grounding Provisions: Welded 1/2 inch (12 millimeter) threaded lug, accessible through handhole.

I. Metal Pole Brackets: Designed to match pole metal. Provide cantilever brackets without underbrace, in sizes and styles indicated, with straight tubular end section to accommodate fixture.

J. Concrete for Pole Foundations:

1. Comply with Section 03 30 00.
2. Use 3000 psig strength, 28 day concrete.

2.03 FINISHES

A. Metal Parts: Manufacturer's standard finish, except as otherwise indicated, applied over corrosion-resistant primer, free of streaks, runs, holidays, stains, blisters, and similar defects. Dark Bronze color.

B. Other Parts: Manufacturer's standard finish, except as otherwise indicated.

PART 3– EXECUTION

3.01 INSTALLATION

A. Set units plumb, square, level, and secure according to manufacturer's written instructions and approved submittals.

B. Concrete Foundations: Construct according to Section 03 30 00.

1. Comply with details and manufacturer's recommendations for reinforcing, anchor bolts, nuts, and washers. Verify anchor-bolt templates by comparing with actual pole bases furnished.
2. Finish: Trowel and rub smooth parts exposed to view.

C. Pole Installation: Use web fabric slings (not chain or cable) to raise and set poles.

D. Fixture Attachment: Fasten to indicated structural supports.

E. Fixture Attachment with Adjustable Features or Aiming: Attach fixtures and supports to allow aiming for indicated light distribution.

3.02 GROUNDING

A. Ground fixtures and metal poles according to Section 26 05 26.

1. Poles: Install 10 feet (3 meters) driven ground rod at each pole.
2. Nonmetallic Poles: Ground metallic components of lighting unit and foundations. Connect fixtures to grounding system with No. 6 AWG conductor.

3.03 FIELD QUALITY CONTROL

A. Inspect each installed unit for damage. Replace damaged fixtures and components.

B. Tests and Observations:

1. Give advance notice of dates and times for field tests.
2. Provide instruments to make and record test results.
3. Replace or repair damaged and malfunctioning units, make necessary adjustments, and retest. Repeat procedure until units operate properly.

3.01 ADJUSTING AND CLEANING

A. Clean units after installation. Use methods and materials recommended by manufacturer.

B. Adjust aimable fixtures to provide required light intensities.

END OF SECTION