PROJECT MANUAL

ADVANCED PROTEIN CRYSTALLIZATION FACILITY (APCF)

9700 S. Cass Avenue
Lemont, IL 60439

CONSTRUCTION DOCUMENTS

PROJECT NO.: **22378.000**

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VOLUME 2 – DIVISIONS 09 - 23

SmithGroup Incorporated
35 East Wacker, Suite 2200
Chicago, IL 60601

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SECTION 09 22 16

NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Non-load-bearing steel framing systems for interior gypsum board assemblies.
2. Suspension systems for interior gypsum ceilings, soffits, and grid systems.

B. Related Sections:
1. Division 05 Section “Cold Formed Metal Framing” for installation and coordination of structural framing not specified in this section.
2. Division 07 Section "Joint Sealants" for installation of joint sealants installed with non-structural metal framing walls and for sealants to the extent not specified in this Section.
3. Division 08 Section "Glazed Aluminum Curtain Walls" for glazed aluminum curtain walls.
4. Division 08 Section “Structural Sealant Glazed Curtain Walls” for structural sealant glazed curtain walls requirements.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:
1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
   a. Include statement indicating cost for each product having recycled content.

1.4 INFORMATION SUBMITTALS

A. Evaluation Reports: For dimpled steel studs and runners firestop tracks, from ICC-ES.

1.5 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.
1. Furnish all labor and materials to completely erect, at an independent testing laboratory, mock-up unit of sufficient size and configuration to demonstrate the performance capabilities of the vertical wall system. Schedule mock-up erection and testing sufficiently in advance of wall system fabrication to cause no delay. Do not install mock-up materials as part of the wall system.
2. Mock-up shall have all details complete and identical to those approved on the wall system shop drawings. Mock-up shall demonstrate quality of materials, finish, and workmanship, as well as compliance with performance requirements.
3. Provide schedule for mock-up fabrication, erection, glazing, sealing and testing a minimum of 30 days in advance of fabrication to permit owner and Architect to coordinate monitoring and observation.
4. Approval of mockups does not constitute approval of deviations from the Contract Documents

contained in mockups unless Architect specifically approves such deviations in writing.

5. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
   a. Location of Mockups as indicated on the Drawings

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. Fire-Test-Response Characteristics: For fire-resistance-rated assemblies that incorporate non-load-bearing steel framing, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing agency.

B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by an independent testing agency.

C. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

2.2 FRAMING SYSTEMS

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Framing Members, General: Comply with ASTM C 754 for conditions indicated.
   1. Steel Sheet Components: Comply with ASTM C 645 requirements for metal unless otherwise indicated.
   2. Protective Coating: ASTM A 653/A 653M, G60, hot-dip galvanized, unless otherwise indicated.

C. Studs and Runners: ASTM C 645. Use either steel studs and runners or dimpled steel studs and runners.
   1. Steel Studs and Runners:
      a. Minimum Base-Metal Thickness: As indicated on Drawings.
      b. Depth: As indicated on Drawings.
   2. Dimpled Steel Studs and Runners:
      a. Minimum Base-Metal Thickness: 0.025 inch.
      b. Depth: As indicated on Drawings.

D. Slip-Type Head Joints: Where indicated, provide one of the following:
   1. Single Long-Leg Runner System: ASTM C 645 top runner with 2-inch- deep flanges in thickness not less than indicated for studs, installed with studs friction fit into top runner and with continuous bridging located within 12 inches of the top of studs to provide lateral bracing.
   2. Double-Runner System: ASTM C 645 top runners, inside runner with 2-inch- deep flanges in thickness not less than indicated for studs and fastened to studs, and outer runner sized to friction fit inside runner.
   3. Deflection Track: Steel sheet top runner manufactured to prevent cracking of finishes applied to interior partition framing resulting from deflection of structure above; in thickness not less than indicated for studs and in width to accommodate depth of studs.
      a. Products: Subject to compliance with requirements, provide one of the following:
         1) Dietrich Metal Framing; SLP-TRK Slotted Deflection Track.
         2) MBA Building Supplies; FlatSteel Deflection Track Slotted Deflecto Track.
         3) Steel Network Inc. (The); VertiClip SLD VertiTrack VTD Series.
         4) Superior Metal Trim; Superior Flex Track System (SFT).
         5) Telling Industries; Vertical Slip Track Vertical Slip Track II.

E. Firestop Tracks: Top runner manufactured to allow partition heads to expand and contract with movement of the structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.

F. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.
   1. Minimum Base-Metal Thickness: As indicated on Drawings.

G. Cold-Rolled Channel Bridging: Steel, 0.053-inch minimum base-metal thickness, with minimum 1/2-inch- wide flanges.
   1. Depth: 1-1/2 inches.
   2. Clip Angle: Not less than 1-1/2 by 1-1/2 inches, 0.068-inch- thick, galvanized steel.

H. Hat-Shaped, Rigid Furring Channels: ASTM C 645.
   1. Minimum Base-Metal Thickness: 0.033 inch.
   2. Depth: As indicated on Drawings.

I. Resilient Furring Channels: 1/2-inch deep, steel sheet members designed to reduce sound transmission.
   1. Configuration: Asymmetrical or hat shaped.

J. Cold-Rolled Furring Channels: 0.053-inch uncoated-steel thickness, with minimum 1/2-inch- wide flanges.
   1. Depth: 3/4 inch.
   2. Furring Brackets: Adjustable, corrugated-edge type of steel sheet with minimum uncoated-steel thickness of 0.033 inch.
   3. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.062-inch diameter wire, or double strand of 0.048-inch diameter wire.

K. Z-Shaped Furring: With slotted or nonslotted web, face flange of 1-1/4 inches, wall attachment flange of 7/8 inch, minimum uncoated-metal thickness of 0.018 inch, and depth required to fit insulation thickness indicated.

2.3 SUSPENSION SYSTEMS

A. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.062-inch- diameter wire, or double strand of 0.048-inch- diameter wire.

B. Hanger Attachments to Concrete:
   1. Anchors: Fabricated from corrosion-resistant materials with holes or loops for attaching wire hangers and capable of sustaining, without failure, a load equal to 5 times that imposed by construction as determined by testing according to ASTM E 488 by an independent testing agency.
      a. Type: Postinstalled, chemical anchor.
   2. Powder-Actuated Fasteners: Suitable for application indicated, fabricated from corrosion-resistant materials with clips or other devices for attaching hangers of type indicated, and capable of sustaining, without failure, a load equal to 10 times that imposed by construction as determined by testing according to ASTM E 1190 by an independent testing agency.

C. Wire Hangers: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.16 inch in diameter.

D. Flat Hangers: Steel sheet, 1 by 3/16 inch by length indicated.

E. Carrying Channels: Cold-rolled, commercial-steel sheet with a base-metal thickness of 0.053 inch and minimum 1/2-inch wide flanges.
   1. Depth: As indicated on Drawings.

2.4 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards.
   1. Fasteners for Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

B. Isolation Strip at Exterior Walls: Provide one of the following:
   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 inch thick, in width to suit steel stud size.

PART 3 - EXECUTION

3.1 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 of the Work.

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

3.2 PREPARATION

A. Suspended Assemblies: Coordinate installation of suspension systems with installation of overhead structure to ensure that inserts and other provisions for anchorages to building structure have been installed to receive hangers at spacing required to support the Work and that hangers will develop their full strength.
   1. Furnish concrete inserts and other devices indicated to other trades for installation in advance of time needed for coordination and construction.

B. Coordination with Sprayed Fire-Resistive Materials:
   1. Before sprayed fire-resistive materials are applied, attach offset anchor plates or ceiling runners (tracks) to surfaces indicated to receive sprayed fire-resistive materials. Where offset anchor plates are required, provide continuous plates fastened to building structure not more than 24 inches o.c.
   2. After sprayed fire-resistive materials are applied, remove them only to extent necessary for installation of non-load-bearing steel framing. Do not reduce thickness of fire-resistive materials below that required for fire-resistance ratings indicated. Protect adjacent fire-resistive materials from damage.

3.3 INSTALLATION, GENERAL

A. Installation Standard: ASTM C 754, except comply with framing sizes and spacing indicated.
   1. Portland Cement Plaster Assemblies: Also comply with requirements in ASTM C 1063 that apply to framing installation.
   2. Gypsum Board Assemblies: Also comply with requirements in ASTM C 840 that apply to framing installation.

B. Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction.

C. Install bracing at terminations in assemblies.

D. Do not bridge building control and expansion joints with non-load-bearing steel framing members. Frame both sides of joints independently.

3.4 INSTALLING FRAMED ASSEMBLIES

A. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.

B. Install studs so flanges within framing system point in same direction.
   1. Space studs as follows:
      a. Multilayer Application: 16 inches o.c. unless otherwise indicated.

C. Install tracks (runners) at floors and overhead supports. Extend framing full height to structural supports or substrates above suspended ceilings, except where partitions are indicated to terminate at suspended ceilings. Continue framing around ducts penetrating partitions above ceiling.
   1. Slip-Type Head Joints: Where framing extends to overhead structural supports, install to produce joints at tops of framing systems that prevent axial loading of finished assemblies.
   2. Fire-Resistance-Rated Partitions: Install framing to comply with fire-resistance-rated assembly indicated and support closures and to make partitions continuous from floor to underside of solid structure.
      a. Firestop Track: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.
   3. Sound-Rated Partitions: Install framing to comply with sound-rated assembly indicated.

D. Direct Furring:
   1. Screw to wood framing.
   2. Attach to concrete or masonry with stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches o.c.

E. Z-Furring Members:
   1. Erect insulation (specified in Section 072100 "Thermal Insulation") vertically and hold in place with Z-furring members spaced 24 inches o.c.
   2. Except at exterior corners, securely attach narrow flanges of furring members to wall with concrete stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches o.c.
   3. At exterior corners, attach wide flange of furring members to wall with short flange extending beyond corner; on adjacent wall surface, screw-attach short flange of furring channel to web of attached channel. At interior corners, space second member no more than 12 inches from corner and cut insulation to fit.

F. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch from the plane formed by faces of adjacent framing.

3.5 INSTALLING SUSPENSION SYSTEMS

A. Install suspension system components in sizes and spacings indicated on Drawings, but not less than those required by referenced installation standards for assembly types and other assembly components indicated.

B. Isolate suspension systems from building structure where they abut or are penetrated by building structure to prevent transfer of loading imposed by structural movement.

C. Suspend hangers from building structure as follows:
   1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or suspension system.
      a. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
   2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that

interfere with locations of hangers required to support standard suspension system members, install supplemental suspension members and hangers in the form of trapezes or equivalent devices.

a. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced installation standards.

3. Wire Hangers: Secure by looping and wire tying, either directly to structures or to inserts, eye screws, or other devices and fasteners that are secure and appropriate for substrate, and in a manner that will not cause hangers to deteriorate or otherwise fail.
4. Flat Hangers: Secure to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices and fasteners that are secure and appropriate for structure and hanger, and in a manner that will not cause hangers to deteriorate or otherwise fail.
5. Do not attach hangers to steel roof deck.
6. Do not attach hangers to permanent metal forms. Furnish cast-in-place hanger inserts that extend through forms.
7. Do not attach hangers to rolled-in hanger tabs of composite steel floor deck.
8. Do not connect or suspend steel framing from ducts, pipes, or conduit.

D. Fire-Resistance-Rated Assemblies: Wire tie furring channels to supports.

E. Seismic Bracing: Sway-brace suspension systems with hangers used for support.

F. Grid Suspension Systems: Attach perimeter wall track or angle where grid suspension systems meet vertical surfaces. Mechanically join main beam and cross-furring members to each other and butt-cut to fit into wall track.

G. Installation Tolerances: Install suspension systems that are level to within 1/8 inch in 12 feet measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

END OF SECTION

SECTION 09 29 00

GYPSUM BOARD

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Interior gypsum board.
2. Tile backing panels.

B. Related Requirements:
1. Section 06 16 00 "Sheathing" for gypsum sheathing for exterior walls.
2. Section 09 22 16 "Non-Structural Metal Framing" for non-structural framing and suspension systems that support gypsum board panels.
3. Section 09 30 00 "Tiling" for cementitious backer units installed as substrates for ceramic tile.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:
1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
   a. Include statement indicating cost for each product having recycled content.
2. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
3. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

C. Samples: For the following products:
1. Trim Accessories: Full-size Sample in 12-inch- long length for each trim accessory indicated.

1.4 DELIVERY, STORAGE AND HANDLING

A. Store materials inside under cover and keep them dry and protected against weather, condensation, direct sunlight, construction traffic, and other potential causes of damage. Stack panels flat and supported on risers on a flat platform to prevent sagging.

1.5 FIELD CONDITIONS

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

B. Do not install paper-faced gypsum panels until installation areas are enclosed and conditioned.

C. Do not install panels that are wet, those that are moisture damaged, and those that are mold damaged.
   1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
   2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by an independent testing agency.

2.2 GYPSUM BOARD, GENERAL

A. Recycled Content of Gypsum Panel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Regional Materials: Gypsum panel products shall be manufactured within 500 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site.

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

2.3 INTERIOR GYPSUM BOARD

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. CertainTeed Corp.
   2. Georgia-Pacific Gypsum LLC.
   3. Lafarge North America Inc.
   4. National Gypsum Company.
   5. USG Corporation.

B. Gypsum Board: ASTM C 1396/C 1396M.
   1. Thickness: 5/8 inch.
   2. Long Edges: Tapered and featured (rounded or beveled) for prefilling.

C. Gypsum Board, Type X: ASTM C 1396/C 1396M.
   1. Thickness: 5/8 inch.
   2. Long Edges: Tapered and featured (rounded or beveled) for prefilling.

D. Gypsum Ceiling Board: ASTM C 1396/C 1396M.
   1. Thickness: 1/2 inch.
   2. Long Edges: Tapered.

E. Abuse-Resistant Gypsum Board: ASTM C 1629/C 1629M, Level 2.

1. Core: 5/8 inch, Type X.
2. Long Edges: Tapered.
3. Mold Resistance: ASTM D 3273, score of 10.

F. Moisture and Mold-Resistant Gypsum Board: ASTM C 1396/C 1396M. With moisture- and mold-resistant core and paper surfaces.
1. Core: 5/8 inch, Type X.
2. Long Edges: Tapered.
3. Mold Resistance: ASTM D 3273, score of 10.

2.4 TILE BACKING PANELS

A. Cementitious Backer Units: ANSI A118.9 and ASTM C 1288 or 1325, with manufacturer's standard edges.
1. Products: Subject to compliance with requirements, provide one of the following:
a. CertainTeed Corp.; FiberCement BackerBoard.
b. James Hardie Building Products, Inc.; Hardiebacker 500.
c. National Gypsum Company, Permabase Cement Board.
d. USG Corporation; DUROCK Cement Board.
2. Thickness: 5/8 inch.
3. Mold Resistance: ASTM D 3273, score of 10 as rated according to ASTM D 3274.

2.5 TRIM ACCESSORIES

A. Interior Trim: ASTM C 1047.
1. Material: Galvanized or aluminum-coated steel sheet or rolled zinc.
2. Shapes:
a. Cornerbead.
b. Bullnose bead.
c. LC-Bead: J-shaped; exposed long flange receives joint compound.
d. L-Bead: L-shaped; exposed long flange receives joint compound.
e. U-Bead: J-shaped; exposed short flange does not receive joint compound.
f. Expansion (control) joint.

B. Aluminum Trim: Extruded accessories of profiles and dimensions indicated.
1. Aluminum: Alloy and temper with not less than the strength and durability properties of ASTM B 221, Alloy 6063-T5.
2. Finish: Corrosion-resistant primer compatible with joint compound and finish materials specified.

2.6 JOINT TREATMENT MATERIALS

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

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

C. Joint Compound for Interior Gypsum Board: 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 edges, and damaged surface areas, use setting-type taping compound.
2. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use setting-type taping or 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 setting-type, sandable topping compound.
5. Skim Coat: For final coat of Level 5 finish, use setting-type, sandable topping compound.

D. Joint Compound for Tile Backing Panels:
1. Cementitious Backer Units: As recommended by backer unit manufacturer.

2.7 AUXILIARY MATERIALS

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

B. Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.
1. Laminating adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Steel Drill Screws: ASTM C 1002, unless otherwise indicated.
1. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch thick.
2. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.

D. Sound Attenuation Blankets: ASTM C 665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.
1. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.
2. Recycled Content of Blankets: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

E. Acoustical Joint Sealant: Manufacturer's standard nonsag, paintable, nonstaining latex sealant complying with ASTM C 834. Product effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.
1. Acoustical joint sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Thermal Insulation: As specified in Section 07 21 00 "Thermal Insulation."

G. Vapor Retarder: As specified in Section 07 21 00 "Thermal Insulation."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and substrates including welded hollow-metal frames and framing, with Installer present, for compliance with requirements and other conditions affecting performance.

B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.

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

3.2 APPLYING AND FINISHING PANELS, GENERAL

A. Comply with ASTM C 840.

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

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

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

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

F. Cover both faces of support framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.
   1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. in area.
   2. Fit gypsum panels around ducts, pipes, and conduits.
   3. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4 to 3/8 inch wide joints to install sealant.

G. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments, except floors. Provide 1/4 to ½ inch wide spaces at these locations and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.

H. Attachment to Steel Framing: Attach panels so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.

I. STC-Rated Assemblies: Seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C 919 and with manufacturer's written recommendations for locating edge trim and closing off sound-flanking paths around or through assemblies, including sealing partitions above acoustical ceilings.

J. Install sound attenuation blankets before installing gypsum panels unless blankets are readily installed after panels have been installed on one side.

3.3 APPLYING INTERIOR GYPSUM BOARD

A. Install interior gypsum board in the following locations:
   1. Wallboard Type: Vertical surfaces unless otherwise indicated.

B. Single-Layer Application:
   1. On ceilings, apply gypsum panels before wall/partition board application to greatest extent possible and at right angles to framing unless otherwise indicated.
   2. On partitions/walls, apply gypsum panels vertically (parallel to framing) unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.
      a. Stagger abutting end joints not less than one framing member in alternate courses of panels.
      b. At stairwells and other high walls, install panels horizontally unless otherwise indicated or required by fire-resistance-rated assembly.
   3. On Z-furring members, apply gypsum panels vertically (parallel to framing) with no end joints. Locate edge joints over furring members.
   4. Fastening Methods: Apply gypsum panels to supports with steel drill screws.

C. Multilayer Application:
   1. On ceilings, apply gypsum board indicated for base layers before applying base layers on walls/partitions; apply face layers in same sequence. Apply base layers at right angles to framing members and offset face-layer joints one framing member, 16 inches minimum, from parallel base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly.
   2. On partitions/walls, apply gypsum board indicated for base layers and face layers vertically (parallel to framing) with joints of base layers located over stud or furring member and face-layer joints offset at least one stud or furring member with base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly. Stagger joints on opposite sides of partitions.
   3. On Z-furring members, apply base layer vertically (parallel to framing) and face layer either vertically (parallel to framing) or horizontally (perpendicular to framing) with vertical joints offset at least one furring member. Locate edge joints of base layer over furring members.
   4. Fastening Methods: Fasten base layers with screws; fasten face layers with adhesive and supplementary fasteners.

D. Laminating to Substrate: Where gypsum panels are indicated as directly adhered to a substrate (other than studs, joists, furring members, or base layer of gypsum board), comply with gypsum board manufacturer's written recommendations and temporarily brace or fasten gypsum panels until fastening adhesive has set.

3.4 APPLYING TILE BACKING PANELS

A. Cementitious Backer Units: ANSI A108.11, at locations indicated to receive tile.

B. Where tile backing panels abut other types of panels in same plane, shim surfaces to produce a uniform plane across panel surfaces.

3.5 INSTALLING TRIM ACCESSORIES

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

B. Control Joints: Install control joints according to ASTM C 840 and in specific locations approved by Architect for visual effect.

C. Interior Trim: Install in the following locations:
   1. Cornerbead: Use at outside corners unless otherwise indicated.
   2. Bullnose Bead: Use at outside corners.
   3. LC-Bead: Use at exposed panel edges.
   4. L-Bead: Use where indicated.

5. U-Bead: Use at exposed panel edges.

D. Aluminum Trim: Install in locations indicated on Drawings.

3.6 FINISHING GYPSUM BOARD

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

B. Prefill open joints, rounded or beveled edges, and damaged surface areas.

C. Apply joint tape over gypsum board joints, except for trim products specifically indicated as not intended to receive tape.

D. Gypsum Board Finish Levels: Finish panels to levels indicated below and according to ASTM C 840:
1. Level 1: Ceiling plenum areas, concealed areas, and where indicated.
2. Level 2: Panels that are substrate for tile Where indicated on Drawings.
3. Level 3: Where indicated on Drawings.
4. Level 4: At panel surfaces that will be exposed to view unless otherwise indicated.
   a. Primer and its application to surfaces are specified in other Section 09 91 23 "Interior Painting." Level 5 is suitable for surfaces receiving gloss and semigloss enamels and other surfaces subject to severe lighting. It is considered a high-quality gypsum board finish.
5. Level 5: Where indicated on Drawings.
   a. Primer and its application to surfaces are specified in other Section 09 91 23 "Interior Painting."

E. Glass-Mat Faced Panels: Finish according to manufacturer's written instructions.

F. Cementitious Backer Units: Finish according to manufacturer's written instructions.

3.7 PROTECTION

A. Protect adjacent surfaces from drywall compound and promptly remove from floors and other non-drywall surfaces. Repair surfaces stained, marred, or otherwise damaged during drywall application.

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

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

END OF SECTION

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SECTION 09 30 00

TILING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Ceramic tile.
2. Waterproof membrane.
3. Crack isolation membrane.
4. Tile backing panels.
5. Metal edge strips.

B. Related Sections:
1. Section 07 92 00 "Joint Sealants" for sealing of expansion, contraction, control, and isolation joints in tile surfaces.
2. Section 09 29 00 "Gypsum Board" for cementitious backer units.

1.3 DEFINITIONS

A. General: Definitions in the ANSI A108 series of tile installation standards and in ANSI A137.1 apply to Work of this Section unless otherwise specified.

B. ANSI A108 Series: ANSI A108.01, ANSI A108.02, ANSI A108.1A, ANSI A108.1B, ANSI A108.1C, ANSI A108.4, ANSI A108.5, ANSI A108.6, ANSI A108.8, ANSI A108.9, ANSI A108.10, ANSI A108.11, ANSI A108.12, ANSI A108.13, ANSI A108.14, ANSI A108.15, ANSI A108.16, and ANSI A108.17, which are contained in "American National Standard Specifications for Installation of Ceramic Tile."

C. Module Size: Actual tile size plus joint width indicated.

D. Face Size: Actual tile size, excluding spacer lugs.

1.4 PERFORMANCE REQUIREMENTS

A. Static Coefficient of Friction: For tile installed on walkway surfaces, provide products with the following values as determined by testing identical products per ASTM C 1028:
1. Level Surfaces: Minimum 0.6.

1.5 ACTION SUBMITTALS

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

B. LEED Submittals:
   1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
      a. Include statement indicating cost for each product having recycled content.
   2. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
   3. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
   4. Product Data for Credit IEQ 4.3: For adhesives and grouts, documentation including printed statement of VOC content.
   5. Product Data for Credit IEQ 4.3: For tile floors, documentation from an independent testing agency indicating compliance with the FloorScore Standard.

C. Shop Drawings: Show locations of each type of tile and tile pattern. Show widths, details, and locations of expansion, contraction, control, and isolation joints in tile substrates and finished tile surfaces.

D. Samples for Initial Selection: For each type of tile and grout indicated. Include Samples of accessories involving color selection.

E. Samples for Verification:
   1. Full-size units of each type and composition of tile and for each color and finish required. For ceramic mosaic tile in color blend patterns, provide full sheets of each color blend.
   2. Assembled samples mounted on a rigid panel, with grouted joints, for each type and composition of tile and for each color and finish required. Make samples at least 12 inches square, but not fewer than 4 tiles. Use grout of type and in color or colors approved for completed Work.
   3. Full-size units of each type of trim and accessory for each color and finish required.
   4. Metal edge strips in 6-inch lengths.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Master Grade Certificates: For each shipment, type, and composition of tile, signed by tile manufacturer and Installer.

C. Product Certificates: For each type of product, signed by product manufacturer.

D. Material Test Reports: For each tile-setting and -grouting product and special purpose tile.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match and are from same production runs as products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Tile and Trim Units: Furnish quantity of full-size units equal to 3 percent of amount installed for each type, composition, color, pattern, and size indicated.
   2. Grout: Furnish quantity of grout equal to 3 percent of amount installed for each type, composition, and color indicated.

1.8 QUALITY ASSURANCE

A. Source Limitations for Tile: Obtain tile of each type and color or finish from one source or producer.
   1. Obtain tile of each type and color or finish from same production run and of consistent quality in appearance and physical properties for each contiguous area.

B. Source Limitations for Setting and Grouting Materials: Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from one manufacturer and each aggregate from one source or producer.

C. Source Limitations for Other Products: Obtain each of the following products specified in this Section from a single manufacturer for each product:
   1. Waterproof membrane.
   2. Crack isolation membrane.
   3. Joint sealants.
   4. Cementitious backer units.
   5. Metal edge strips.

D. Installation method: All tile greater than 12 inches in either dimension shall be installed with the Tuscan Leveling System to control lippage and other related installation control activities.
   1. Installation guidelines available at: www.tuscanleveling.com

E. Preinstallation Conference: Conduct conference at Project site.
   1. Review requirements in ANSI A108.01 for substrates and for preparation by other trades.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use. Comply with requirements in ANSI A137.1 for labeling tile packages.

B. Store tile and cementitious materials on elevated platforms, under cover, and in a dry location.

C. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.

D. Store liquid materials in unopened containers and protected from freezing.

E. Handle tile that has temporary protective coating on exposed surfaces to prevent coated surfaces from contacting backs or edges of other units. If coating does contact bonding surfaces of tile, remove coating from bonding surfaces before setting tile.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Do not install tile until construction in spaces is complete and ambient temperature and humidity conditions are maintained at the levels indicated in referenced standards and manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 PRODUCTS, GENERAL

A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.
   1. Provide tile complying with Standard grade requirements unless otherwise indicated.

B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI A108.02, ANSI standards referenced in other Part 2 articles, ANSI standards referenced by TCA installation methods specified in tile installation schedules, and other requirements specified.

C. FloorScore Compliance: Tile for floors shall comply with requirements of FloorScore Standard.

D. Factory Blending: For tile exhibiting color variations within ranges, blend tile in factory and package so tile units taken from one package show same range in colors as those taken from other packages and match approved Samples.

E. Mounting: For factory-mounted tile, provide back- or edge-mounted tile assemblies as standard with manufacturer unless otherwise indicated.
   1. Where tile is indicated for installation in wet areas, do not use back- or edge-mounted tile assemblies unless tile manufacturer specifies in writing that this type of mounting is suitable for installation indicated and has a record of successful in-service performance.

F. Factory-Applied Temporary Protective Coating: Where indicated under tile type, protect exposed surfaces of tile against adherence of mortar and grout by precoating with continuous film of petroleum paraffin wax, applied hot. Do not coat unexposed tile surfaces.

2.2 TILE PRODUCTS

A. Refer to Finish Schedule included on Drawing Sheet A10.0.0 for Tile Types: T-1 through T-7

B. Accessories: Provide vitreous china accessories of type and size indicated, suitable for installing by same method as adjoining wall tile.
   1. Color and Finish: Match adjoining glazed wall tile.

2.3 TILE BACKING PANELS

A. Cementitious Backer Units: ANSI A118.9 or ASTM C 1325, in maximum lengths available to minimize end-to-end butt joints.
   1. Thickness: As indicated.

2.4 WATERPROOF MEMBRANE

A. General: Manufacturer's standard product that complies with ANSI A118.10 and is recommended by the manufacturer for the application indicated. Include reinforcement and accessories recommended by manufacturer.

B. Chlorinated Polyethylene Sheet: Nonplasticized, chlorinated polyethylene faced on both sides with nonwoven polyester fabric; 0.030-inch nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Noble Company (The); Nobleseal TS.

C. PVC Sheet: Two layers of PVC sheet heat-fused together and to facings of nonwoven polyester; 0.040-inch nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Compotite Corporation; Composeal Gold.

D. Polyethylene Sheet: Polyethylene faced on both sides with fleece webbing; 0.008-inch nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Schluter Systems L.P.; KERDI.

E. Fabric-Reinforced, Modified-Bituminous Sheet: Self-adhering, SBS-modified-bituminous sheet with woven reinforcement facing; 0.040-inch nominal thickness.

F. Fabric-Reinforced, Fluid-Applied Membrane: System consisting of liquid-latex rubber or elastomeric polymer and continuous fabric reinforcement.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Boiardi Products; a QEP company; Elastiment 344 Reinforced Waterproofing and Anti-Fracture/Crack Suppression Membrane.
      b. Bonsal American; an Oldcastle company; B 6000 Waterproof Membrane with Glass Fabric.
      c. Bostik, Inc.; Hydroment Blacktop 90210.
      d. Custom Building Products; 9240 Waterproofing and Anti-Fracture Membrane.
      e. Laticrete International, Inc.; Laticrete 9235 Waterproof Membrane.
      f. MAPEI Corporation; Mapelastic HPG with MAPEI Fiberglass Mesh.
      g. Mer-Kote Products, Inc.; Hydro-Guard 2000.
      h. Summitville Tiles, Inc.; S-9000.

G. Fluid-Applied Membrane: Liquid-latex rubber or elastomeric polymer.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Boiardi Products; a QEP company; Elastiment 644 Membrane Waterproofing System.
      b. Bonsal American; an Oldcastle company; B 6000 Waterproof Membrane.
      c. Bostik, Inc.; Durabond D-222 Duraguard Membrane.
      d. C-Cure; Pro-Red Waterproofing Membrane 63.
      e. Custom Building Products; Redgard Waterproofing and Crack Prevention Membrane.
      f. Jamo Inc.; Waterproof.
      g. Laticrete International, Inc.; Laticrete Watertight Floor N' Wall Waterproofing.
      h. MAPEI Corporation; Mapelastic HPG.
      i. Southern Grouts & Mortars, Inc.; Southcrete 1100 Crack Suppression and Waterproofing.
      j. TEC; a subsidiary of H. B. Fuller Company; HydraFlex - Waterproofing Crack Isolation Membrane.

H. Latex-Portland Cement: Flexible mortar consisting of cement-based mix and latex additive.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Boiardi Products; a QEP company; Elastiment 323 Cement Based Waterproofing, Anti-Fracture/Crack Suppression Membrane.
      b. C-Cure; UltraCure 971.
      c. MAPEI Corporation; Mapelastic (PRP 315).
      d. Southern Grouts & Mortars, Inc.; Southcrete 1100.
      e. TEC; a subsidiary of H. B. Fuller Company; Triple Flex Waterproofing, Crack Isolation Membrane & Mortar.

I. Urethane Waterproofing and Tile-Setting Adhesive: One-part, liquid-applied urethane, with a VOC content of 65 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24),in a consistency suitable for trowel application and intended for use as both waterproofing and tile-setting adhesive in a two-step process.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Bostik, Inc.; Durabond D-200 or Hydroment Ultra-Set.

2.5 CRACK ISOLATION MEMBRANE

A. General: Manufacturer's standard product, selected from the following, that complies with ANSI A118.12 for standard performance and is recommended by the manufacturer for the application indicated. Include reinforcement and accessories recommended by manufacturer.

B. Chlorinated Polyethylene Sheet: Nonplasticized, chlorinated polyethylene faced on both sides with nonwoven polyester fabric; 0.030-inch nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Noble Company (The); Nobleseal CIS.

C. PVC Sheet: Two layers of PVC sheet heat-fused together and to facings of nonwoven polyester; 0.040-inch nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Compotite Corporation; Composeal Gold.

D. Polyethylene Sheet: Polyethylene faced on both sides with fleece webbing; 0.008-inch nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Schluter Systems L.P.; KERDI.

E. Corrugated Polyethylene: Corrugated polyethylene with dovetail-shaped corrugations and with anchoring webbing on the underside; 3/16-inch nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Schluter Systems L.P.; DITRA.

F. Fabric-Reinforced, Modified-Bituminous Sheet: Self-adhering, modified-bituminous sheet with fabric reinforcement facing; 0.040-inch nominal thickness.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. MAPEI Corporation; Mapelastic SM.
      b. National Applied Construction Products, Inc.; Strataflex.

G. Fabric-Reinforced, Fluid-Applied Membrane: System consisting of liquid-latex rubber or elastomeric polymer and fabric reinforcement.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Boiardi Products; a QEP company; Elastiment 344 Reinforced Waterproofing and Anti-Fracture/Crack Suppression Membrane.
      b. Bonsal American; an Oldcastle company; B 6000 Waterproof Membrane with Glass Fabric.
      c. Bostik, Inc.; Hydroment Blacktop 90210.
      d. Custom Building Products; 9240 Waterproofing and Anti-Fracture Membrane.
      e. Laticrete International, Inc.; Laticrete 9235 Waterproof Membrane.
      f. MAPEI Corporation; Mapelastic L (PRP M19).
      g. Mer-Kote Products, Inc.; Hydro-Guard 2000.
      h. Summitville Tiles, Inc.; S-9000.

H. Fluid-Applied Membrane: Liquid-latex rubber or elastomeric polymer.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Bostik, Inc.; Durabond D-222 Duraguard Membrane.
      b. C-Cure; CureLastic 949.
      c. Custom Building Products; Redgard Waterproofing and Crack Prevention Membrane.
      d. Jamo Inc.; Waterproof.
      e. Mer-Kote Products, Inc.; Fracture-Guard 5000.
      f. Southern Grouts & Mortars, Inc.; Southcrete 1100 Crack Suppression and Waterproofing.
      g. TEC; a subsidiary of H. B. Fuller Company; HydraFlex - Waterproofing Crack Isolation Membrane.

I. Latex-Portland Cement: Flexible mortar consisting of cement-based mix and latex additive.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. C-Cure; UltraCure 971.
      b. MAPEI Corporation; Mapelastic (PRP 315).
      c. TEC; a subsidiary of H. B. Fuller Company; Triple Flex Waterproofing, Crack Isolation Membrane & Mortar.

J. Urethane Crack Isolation Membrane and Tile-Setting Adhesive: One-part, liquid-applied urethane, with a VOC content of 65 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24),in a consistency suitable for trowel application and intended for use as both waterproofing and tile-setting adhesive in a two-step process.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Bostik, Inc.; Durabond D-200 or Hydroment Ultra-Set.

2.6 SETTING MATERIALS

A. Portland Cement Mortar (Thickset) Installation Materials: ANSI A108.02.
   1. Cleavage Membrane: Asphalt felt, ASTM D 226, Type I (No. 15); or polyethylene sheeting, ASTM D 4397, 4.0 mils thick.
   2. Reinforcing Wire Fabric: Galvanized, welded wire fabric, 2 by 2 inches by 0.062-inch diameter; comply with ASTM A 185 and ASTM A 82 except for minimum wire size.
   3. Latex Additive: Manufacturer's standard water emulsion, serving as replacement for part or all of gaging water, of type specifically recommended by latex-additive manufacturer for use with field-mixed portland cement and aggregate mortar bed.

B. Latex-Portland Cement Mortar (Thin Set): ANSI A118.4.
   1. Provide prepackaged, dry-mortar mix containing dry, redispersible, vinyl acetate or acrylic additive to which only water must be added at Project site.
   2. Provide prepackaged, dry-mortar mix combined with acrylic resin or styrene-butadiene-rubber liquid-latex additive at Project site.
   3. For wall applications, provide mortar that complies with requirements for nonsagging mortar in addition to the other requirements in ANSI A118.4.

C. Medium-Bed, Latex-Portland Cement Mortar: Comply with requirements in ANSI A118.4. Provide product that is approved by manufacturer for application thickness of 5/8 inch.
   1. Provide prepackaged, dry-mortar mix containing dry, redispersible, vinyl acetate or acrylic additive to which only water must be added at Project site.
   2. Provide prepackaged, dry-mortar mix combined with acrylic resin or styrene-butadiene-rubber liquid-latex additive at Project site.

D. Water-Cleanable, Tile-Setting Epoxy: ANSI A118.3., with a VOC content of 65 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   1. Provide product capable of withstanding continuous and intermittent exposure to temperatures of up to 140 deg F and 212 deg F, respectively, and certified by manufacturer for intended use.

E. Organic Adhesive: ANSI A136.1, Type I., with a VOC content of 65 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 GROUT MATERIALS

A. Water-Cleanable Epoxy Grout: ANSI A118.3, with a VOC content of 65 g/L or less when calculated according to 40 CFR 59, Subpart D.
   1. Provide product capable of withstanding continuous and intermittent exposure to temperatures of up to 140 deg F and 212 deg F, respectively, and certified by manufacturer for intended use.

B. Chemical-Resistant Furan Grout: ANSI A118.5, with carbon filler, with a VOC content of 65 g/L or less when calculated according to 40 CFR 59, Subpart D.

C. Grout for Pregrouted Tile Sheets: Same product used in factory to pregrout tile sheets.

2.8 ELASTOMERIC SEALANTS

A. General: Provide sealants, primers, backer rods, and other sealant accessories that comply with the following requirements and with the applicable requirements in Section 079200 "Joint Sealants."
   1. Sealants shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Use primers, backer rods, and sealant accessories recommended by sealant manufacturer.

B. Colors: Provide colors of exposed sealants to match colors of grout in tile adjoining sealed joints unless otherwise indicated.

C. One-Part, Mildew-Resistant Silicone Sealant: ASTM C 920; Type S; Grade NS; Class 25; Uses NT, G, A, and, as applicable to nonporous joint substrates indicated, O; formulated with fungicide, intended for sealing interior ceramic tile joints and other nonporous substrates that are subject to in-service exposures of high humidity and extreme temperatures.

D. Multipart, Pourable Urethane Sealant for Use T: ASTM C 920; Type M; Grade P; Class 25; Uses T, M, A, and, as applicable to joint substrates indicated, O.

E. Chemical-Resistant Sealants: For chemical-resistant floors, provide chemical-resistant elastomeric sealant of type recommended and produced by chemical-resistant mortar and grout manufacturer for type of application indicated, with proven service record and compatibility with tile and other setting materials, and with chemical resistance equivalent to mortar/grout.

2.9 MISCELLANEOUS MATERIALS

A. Trowelable Underlayments and Patching Compounds: Latex-modified, portland cement-based formulation provided or approved by manufacturer of tile-setting materials for installations indicated.

B. Metal Edge Strips: Angle or L-shape, height to match tile and setting-bed thickness, metallic or combination of metal and PVC or neoprene base, designed specifically for flooring applications; stainless-steel, ASTM A 666, 300 Series exposed-edge material.

C. Temporary Protective Coating: Product indicated below that is formulated to protect exposed surfaces of tile against adherence of mortar and grout; compatible with tile, mortar, and grout products; and easily removable after grouting is completed without damaging grout or tile.
   1. Grout release in form of manufacturer's standard proprietary liquid coating that is specially formulated and recommended for use as temporary protective coating for tile.

D. Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.

E. Grout Sealer: Manufacturer's standard product for sealing grout joints and that does not change color or appearance of grout.

2.10 MIXING MORTARS AND GROUT

A. Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.

B. Add materials, water, and additives in accurate proportions.

C. Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of installed tile.
   1. Verify that substrates for setting tile are firm, dry, clean, free of coatings that are incompatible with tile-setting materials including curing compounds and other substances that contain soap, wax, oil, or silicone; and comply with flatness tolerances required by ANSI A108.01 for installations indicated.
   2. Verify that concrete substrates for tile floors installed with adhesives, bonded mortar bed, or thin-set mortar comply with surface finish requirements in ANSI A108.01 for installations indicated.
      a. Verify that surfaces that received a steel trowel finish have been mechanically scarified.
      b. Verify that protrusions, bumps, and ridges have been removed by sanding or grinding.
   3. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind tile has been completed.
   4. Verify that joints and cracks in tile substrates are coordinated with tile joint locations; if not coordinated, adjust joint locations in consultation with Architect.

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

3.2 PREPARATION

A. Fill cracks, holes, and depressions in concrete substrates for tile floors installed with adhesives or thin-set mortar with trowelable leveling and patching compound specifically recommended by tile-setting material manufacturer.

B. Where indicated, prepare substrates to receive waterproofing by applying a reinforced mortar bed that complies with ANSI A108.1A and is sloped 1/4 inch per foot toward drains.

C. Blending: For tile exhibiting color variations, verify that tile has been factory blended and packaged so tile units taken from one package show same range of colors as those taken from other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.

D. Field-Applied Temporary Protective Coating: If indicated under tile type or needed to prevent grout from staining or adhering to exposed tile surfaces, precoat them with continuous film of temporary protective coating, taking care not to coat unexposed tile surfaces.

3.3 TILE INSTALLATION

A. Comply with TCA's "Handbook for Ceramic Tile Installation" for TCA installation methods specified in tile installation schedules. Comply with parts of the ANSI A108 Series "Specifications for Installation of Ceramic Tile" that are referenced in TCA installation methods, specified in tile installation schedules, and apply to types of setting and grouting materials used.
   1. For the following installations, follow procedures in the ANSI A108 Series of tile installation standards for providing 95 percent mortar coverage:
      a. Tile floors in wet areas.
      b. Tile floors composed of tiles 8 by 8 inches or larger.

B. Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.

C. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.

D. Provide manufacturer's standard trim shapes where necessary to eliminate exposed tile edges.

E. Jointing Pattern: Lay tile in grid pattern unless otherwise indicated. Lay out tile work and center tile fields in both directions in each space or on each wall area. Lay out tile work to minimize the use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated.
   1. For tile mounted in sheets, make joints between tile sheets same width as joints within tile sheets so joints between sheets are not apparent in finished work.
   2. Where adjoining tiles on floor, base, walls, or trim are specified or indicated to be same size, align joints.
   3. Where tiles are specified or indicated to be whole integer multiples of adjoining tiles on floor, base, walls, or trim, align joints unless otherwise indicated.

F. Joint Widths: Unless otherwise indicated, install tile with the following joint widths:
   1. Ceramic Mosaic Tile: 1/16 inch.
   2. Glazed Wall Tile: 1/16 inch.

G. Lay out tile wainscots to dimensions indicated or to next full tile beyond dimensions indicated.

H. Expansion Joints: Provide expansion joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated. Form joints during installation of setting materials, mortar beds, and tile. Do not saw-cut joints after installing tiles.
   1. Where joints occur in concrete substrates, locate joints in tile surfaces directly above them.

I. Metal Edge Strips: Install at locations indicated or where exposed edge of tile flooring meets carpet, wood, or other flooring that finishes flush with top of tile.

J. Grout Sealer: Apply grout sealer to cementitious grout joints in tile floors according to grout-sealer manufacturer's written instructions. As soon as grout sealer has penetrated grout joints, remove excess sealer and sealer from tile faces by wiping with soft cloth.

3.4 TILE BACKING PANEL INSTALLATION

A. Install cementitious backer units and treat joints according to ANSI A108.11 and manufacturer's written instructions for type of application indicated.

3.5 WATERPROOFING INSTALLATION

A. Install waterproofing to comply with ANSI A108.13 and manufacturer's written instructions to produce waterproof membrane of uniform thickness and bonded securely to substrate.

B. Do not install tile or setting materials over waterproofing until waterproofing has cured and been tested to determine that it is watertight.

3.6 CRACK ISOLATION MEMBRANE INSTALLATION

A. Install crack isolation membrane to comply with ANSI A108.17 and manufacturer's written instructions to produce membrane of uniform thickness and bonded securely to substrate.

B. Do not install tile or setting materials over crack isolation membrane until membrane has cured.

3.7 CLEANING AND PROTECTING

A. Cleaning: On completion of placement and grouting, clean all ceramic tile surfaces so they are free of foreign matter.
   1. Remove epoxy and latex-portland cement grout residue from tile as soon as possible.
   2. Clean grout smears and haze from tile according to tile and grout manufacturer's written instructions but no sooner than 10 days after installation. Use only cleaners recommended by tile and grout manufacturers and only after determining that cleaners are safe to use by testing on samples of tile and other surfaces to be cleaned. Protect metal surfaces and plumbing fixtures from effects of cleaning. Flush surfaces with clean water before and after cleaning.
   3. Remove temporary protective coating by method recommended by coating manufacturer and that is acceptable to tile and grout manufacturer. Trap and remove coating to prevent drain clogging.

B. Protect installed tile work with kraft paper or other heavy covering during construction period to prevent staining, damage, and wear. If recommended by tile manufacturer, apply coat of neutral protective cleaner to completed tile walls and floors.

C. Prohibit foot and wheel traffic from tiled floors for at least seven days after grouting is completed.

D. Before final inspection, remove protective coverings and rinse neutral protective cleaner from tile surfaces.

3.8 INTERIOR TILE INSTALLATION SCHEDULE

A. Interior Floor Installations, Concrete Subfloor:
   1. Tile Installation F112: Cement mortar bed (thickset) bonded to concrete; TCA F112 and ANSI A108.1B.

2. Tile Installation F114: Cement mortar bed (thickset) with cleavage membrane; epoxy furan grout; TCA F114 and ANSI A108.1B.
   a. Thin-Set Mortar for Cured-Bed Method: Latex- Medium-bed, latex- portland cement mortar.
   b. Grout: Water-cleanable epoxy Chemical-resistant furan grout.
3. Tile Installation F122: Thin-set mortar on waterproof membrane; TCA F122.
   a. Thin-Set Mortar: Latex- portland cement mortar.
   b. Grout: Polymer-modified grout.
4. Tile Installation F132: Water-cleanable, tile-setting epoxy on cured cement mortar bed bonded to concrete subfloor ; epoxy grout; TCA F132.
   a. Grout: Water-cleanable epoxy grout.

B. Interior Wall Installations, Metal Studs or Furring:
   1. Tile Installation W244: Thin-set mortar on cementitious backer units or fiber cement underlayment; TCA W244.
      a. Thin-Set Mortar: Latex- portland cement mortar.
      b. Grout: Water-cleanable epoxy grout.

END OF SECTION

SECTION 09 30 33

STONE TILING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Dimension stone tile and related setting materials applied to floors and walls.
2. Stone thresholds.
3. Waterproof membrane.
4. Crack isolation membrane.
5. Metal edge strips.

B. Related Sections:
1. Division 03 Section "Cast-in-Place Concrete" for monolithic slab finishes specified for tile substrates.
2. Division 09 Section "Gypsum Board" for cementitious backer units.

1.3 DEFINITIONS

A. Dimension Stone Tile: Modular stone units less than 3/4 inch thick.

B. Module Size: Actual tile size plus joint width.

C. Polished Finish: Smooth surface that produces sharp, mirrorlike reflections. Reflected images of overhead fluorescent tubes have straight lines without visible distortion when viewed at arm's length.

D. Honed Finish: Smooth, nonreflective surface similar to that produced by grinding with a 400- to 1200-grit abrasive; with a gap not exceeding 0.005 inch (0.13 mm) when faces are tested for flatness with a 24-inch straightedge.

E. Sand-Rubbed Finish: Uniform, fine-textured surface similar to that produced by grinding with a 40-grit abrasive; with a gap not exceeding 1/32 inch (0.8 mm) when faces are tested for flatness with a 24-inch straightedge.

F. Thermal Finish: Uniform, coarse-textured surface produced by thermal shock; with a gap not exceeding 3/16 inch when faces are tested for flatness with a 24-inch straightedge.

G. Natural-Cleft Finish: Uneven surface produced by splitting stone along a natural cleavage plane; without visible tool marks and with a gap not exceeding 3/16 inch when faces are tested for flatness with a 24-inch straightedge.

1.4 ACTION SUBMITTALS

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

B. LEED Submittals:
   1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
      a. Include statement indicating cost for each product having recycled content.
   2. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
   3. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
   4. Product Data for Credit IEQ 4.3: For adhesives and grouts, documentation including printed statement of VOC content.
   5. Product Data for Credit IEQ 4.3: For stone tile floors, documentation from an independent testing agency indicating compliance with the FloorScore Standard.

C. Shop Drawings: Show locations of each type of stone tile and tile pattern. Show widths, details, and locations of expansion, contraction, control, and isolation joints in substrates and finished stone tile surfaces. Show stone thresholds.

D. Samples for Initial Selection: For each type of grout indicated and accessories involving color selection.

E. Samples for Verification:
   1. Full-size units of each type of stone tile in each finish required.
   2. Assembled Samples with grouted joints for each type of stone tile and for each finish required, at least 36 inches square and mounted on a rigid panel. Use grout of type and in color(s) approved for completed Work.
   3. Range Samples consisting of at least three full-size units of each type of stone tile, exhibiting extremes of the full range of color and other visual characteristics expected. Range Samples establish the standard by which individual stone tiles and thresholds will be judged.
   4. Stone thresholds in 6-inch lengths.
   5. Metal edge strips in 6-inch lengths.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For dimension stone tile to include in maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match and are from same production runs as products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Dimension Stone Tile: Furnish quantity of full-size units equal to 3 percent of amount installed, for each type, composition, color, pattern, and size indicated.
      a. Grout: Furnish quantity of grout equal to 3 percent of amount installed for each type, composition, and color indicated.

1.8 QUALITY ASSURANCE

A. Supplier Qualifications: A firm experienced in supplying products similar to those indicated for the Project and with a record of successful in-service performance.

B. Source Limitations for Stone Tile and Thresholds: Obtain each stone product type through single source from single producer.
   1. For each stone product type, provide one stone variety.
   2. Where two or more stone product types are identical except for size or finish, provide same variety for each type.
   3. Where threshold types are identical to stone tile types except for size or finish, provide same variety.
   4. Obtain each variety of stone from same location in a single quarry with resources to provide materials of consistent quality in appearance and physical properties.

C. Source Limitations for Setting and Grouting Materials: Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from single manufacturer and each aggregate from single source or producer.

D. Source Limitations for Other Products: Obtain each of the following products specified in this Section from a single manufacturer for each product:
   1. Waterproof membrane.
   2. Crack isolation membrane.
   3. Joint sealants.
   4. Cementitious backer units.
   5. Metal edge strips.

E. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Build mockup of each type of stone floor tile installation.
   2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

F. Dry-Laid Mockups: Lay out tiles in dry-laid mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Lay out mockup of each type of stone floor tile installation.
   2. Maintain dry-laid mockups in an undisturbed condition until equivalent areas of the completed Work are approved to serve as mockups.

G. Installation method: All tile greater than 12 inches in either dimension shall be installed with the Tuscan Leveling System to control lippage and other related installation control activities.
   1. Installation guidelines available at: www.tuscanleveling.com

H. Preinstallation Conference: Conduct conference at Project site.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use.

B. Store stone tile and cementitious materials on elevated platforms, under cover, and in a dry location.

C. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.

D. Store liquid materials in unopened containers and protected from freezing.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Do not install stone tile until construction in spaces is complete and ambient temperature and humidity conditions are maintained at the levels indicated in referenced standards and manufacturer's written instructions.

1.11 SEQUENCING AND SCHEDULING

A. Sequence stone tile installation with other work to minimize possibility of damage and soiling during remainder of construction period.

B. Install stone tile and accessories only after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 STONE PRODUCTS

A. Varieties and Sources: Subject to compliance with requirements, provide products manufactured in the United States that may be incorporated into the Work include, those indicated in the schedule below.
   1. Basis of Design
   2. Contact: Stonesource Midwest, John Gordon (312-970-5694)

ST-1A

Manuf.:	Trend USA Ltd
Product:	Trend Q
Color:	431 White Cristallino
Size:	24" X 118"
Grout:	Provide Samples for Review
Installation:	Refer To Finish Plan
Location:	South Corridor
Note:	Adhesive per manufacturer’s recommendation

ST-1B

Manuf.:	Trend USA Ltd
Product:	Trend Q
Color:	431 White Cristallino
Size:	24" X 59"
Grout:	Provide Samples for Review
Installation:	Refer To Finish Plan
Location:	South Corridor
Note:	Adhesive per manufacturer’s recommendation

ST-1C

Manuf.:	Trend USA Ltd
Product:	Trend Q
Color:	431 White Cristallino
Size:	16" X 48"
Grout:	Provide Samples for Review
Installation:	Refer To Finish Plan
Location:	South Corridor
Note:	Adhesive per manufacturer’s recommendation

ST-2

Manuf.:	Trend USA, Ltd
Product:	Trend Q
Color:	634 Grigio Stella
Size:	48" X 16"
Grout:	Provide Samples for Review
Installation:	Refer To Finish Plan
Location:	South Corridor
Note:	Adhesive per manufacturer’s recommendation

ST-3

Manuf.:	Trend USA Ltd
Product:	Trend Q
Color:	431 White Cristallino
Size:	16" X 48" Slab cut to create wall base
Grout:	Provide Samples for Review
Installation:	Refer To Finish Plan
Location:	South Corridor
Note:	Adhesive per manufacturer’s recommendation

ST-4

Manuf.:	Icestone
Product:	Recycled glass and concrete composite resurfacing
Color:	Alpine White
Finish:	Polished
Thickness	1.25"
Location:	Conference center credenza tops
Note:	Seal and Wax per manufacturer's Recommendation
Contact:	Stones Design inc., Chris Sorrel (630.545.4288)

B. Regional Materials: Provide stone tiles and thresholds that have been manufactured within 500 miles of Project site from stone that has been extracted within 500 miles of Project site.

C. FloorScore Compliance: Stone tile for floors shall comply with requirements of FloorScore Standard.

D. Low-Emitting Materials: Stone tile flooring systems shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Abrasion Resistance of Stone Tile for Floors: Provide stone with a value of not less than 12, as determined per ASTM C 1353 or ASTM C 241.

F. Static Coefficient of Friction of Stone Tile for Floors: Provide products with the following values as determined by testing identical products per ASTM C 1028:
   1. Level Surfaces: Minimum 0.7

G. Provide stone products that are free of defects impairing their function for use indicated, including cracks, seams, and starts.

H. Pattern Orientation: For stone varieties with a directional pattern, provide tile with pattern oriented parallel to one side of tile.

2.2 WATERPROOF MEMBRANES

A. General: Manufacturer's standard product, selected from the following, that complies with ANSI A118.10 and is recommended by the manufacturer for the application indicated. Include reinforcement and accessories recommended by manufacturer.

B. Chlorinated Polyethylene Sheet: Nonplasticized, chlorinated polyethylene faced on both sides with nonwoven polyester fabric; 0.030-inch (0.76-mm) nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Noble Company (The); Nobleseal TS.

C. PVC Sheet: Two layers of PVC sheet heat-fused together and to facings of nonwoven polyester; 0.040-inch (1.01-mm) nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Compotite Corporation; Composeal Gold.

D. Polyethylene Sheet: Polyethylene faced on both sides with fleece webbing; 0.008-inch (0.203-mm) nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Schluter Systems L.P.; KERDI..

E. Fabric-Reinforced, Modified-Bituminous Sheet: Self-adhering, SBS-modified-bituminous sheet with woven reinforcement facing; 0.040-inch (1.01-mm) nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. National Applied Construction Products, Inc.; Strataflex.

F. Fabric-Reinforced, Fluid-Applied Membrane: System consisting of liquid-latex rubber or elastomeric polymer and continuous fabric reinforcement.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Boiardi Products, a QEP company; Elastiment 344 Reinforced Waterproofing and Anti-Fracture/Crack Suppression Membrane.
      b. Bonsal American, an Oldcastle company; B 6000 Waterproof Membrane with Glass Fabric.
      c. Bostik, Inc.; Hydroment Blacktop 90210.
      d. Custom Building Products; 9240 Waterproofing and Anti-Fracture Membrane.
      e. Laticrete International, Inc.; Laticrete 9235 Waterproof Membrane.
      f. MAPEI Corporation; Mapelastic HPG with MAPEI Fiberglass Mesh.
      g. Mer-Kote Products, Inc.; Hydro-Guard 2000.
      h. Summitville Tiles, Inc.; S-9000.

G. Fluid-Applied Membrane: Liquid-latex rubber or elastomeric polymer.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Boiardi Products, a QEP company; Elastiment 644 Membrane Waterproofing System.
      b. Bonsal American, an Oldcastle company; B 6000 Waterproof Membrane.
      c. Bostik, Inc.; Durabond D-222 Duraguard Membrane.
      d. C-Cure; Pro-Red Waterproofing Membrane 63.
      e. Custom Building Products; Redgard Waterproofing and Crack Prevention Membrane.
      f. Jamo Inc.; Waterproof.
      g. Laticrete International, Inc.; Latapoxy 24hr HydroProofing or Laticrete Watertight Floor N' Wall Waterproofing.
      h. MAPEI Corporation; Mapelastic HPG.
      i. Southern Grouts & Mortars, Inc.; Southcrete 1100 Crack Suppression and Waterproofing.
      j. TEC, a subsidiary of H. B. Fuller Company; HydraFlex - Waterproofing Crack Isolation Membrane.

H. Latex-Portland Cement: Flexible mortar consisting of cement-based mix and latex additive.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Boiardi Products, a QEP company; Elastiment 323 Cement Based Waterproofing, Anti-Fracture/Crack Suppression Membrane.
      b. C-Cure; UltraCure 971.
      c. MAPEI Corporation; Mapelastic (PRP 315).
      d. Southern Grouts & Mortars, Inc.; Southcrete 1100.
      e. TEC, a subsidiary of H. B. Fuller Company; Triple Flex Waterproofing, Crack Isolation Membrane & Mortar.

I. Urethane Waterproofing and Tile-Setting Adhesive: One-part, liquid-applied urethane, with a VOC content of 65 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), in a consistency suitable for trowel application and intended for use as both waterproofing and tile-setting adhesive in a two-step process.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Bostik, Inc.; Durabond D-200 or Hydroment Ultra-Set or Hydroment Ultra-Set Advanced.

2.3 CRACK ISOLATION MEMBRANES

A. General: Manufacturer's standard product, selected from the following, that complies with ANSI A118.12 for high performance and is recommended by the manufacturer for the application indicated. Include reinforcement and accessories recommended by manufacturer.

B. Chlorinated Polyethylene Sheet: Nonplasticized, chlorinated polyethylene faced on both sides with nonwoven polyester fabric; 0.030-inch (0.76-mm) nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Noble Company (The); Nobleseal CIS.

C. PVC Sheet: Two layers of PVC sheet heat-fused together and to facings of nonwoven polyester; 0.040-inch (1.01-mm) nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Compotite Corporation; Composeal Gold.

D. Polyethylene Sheet: Polyethylene faced on both sides with fleece webbing; 0.008-inch (0.203-mm) nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Schluter Systems L.P.; KERDI.

E. Corrugated Polyethylene: Corrugated polyethylene with dovetail-shaped corrugations and with anchoring webbing on the underside; 1/8-inch (3-mm) nominal thickness.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Schluter Systems L.P.; DITRA.

F. Fabric-Reinforced, Modified-Bituminous Sheet: Self-adhering, modified-bituminous sheet with fabric reinforcement facing; 0.040-inch (1.01-mm) nominal thickness.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. MAPEI Corporation; Mapelastic SM.
      b. National Applied Construction Products, Inc.; Strataflex.

G. Fabric-Reinforced, Fluid-Applied Membrane: System consisting of liquid-latex rubber or elastomeric polymer and fabric reinforcement.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Boiardi Products, a QEP company; Elastiment 344 Reinforced Waterproofing and Anti-Fracture/Crack Suppression Membrane.

b. Bonsal American, an Oldcastle company; B 6000 Waterproof Membrane with Glass Fabric.
c. Bostik, Inc.; Hydroment Blacktop 90210.
d. Custom Building Products; 9240 Waterproofing and Anti-Fracture Membrane.
e. Laticrete International, Inc.; Laticrete Blue 92 Anti-Fracture Membrane or 9235 Waterproof Membrane.
f. MAPEI Corporation; Mapelastic L (PRP M19) or Mapelastic HPG with MAPEI Fiberglass Mesh.
g. Mer-Kote Products, Inc.; Hydro-Guard 2000.
h. Summitville Tiles, Inc.; S-9000.

H. Fluid-Applied Membrane: Liquid-latex rubber or elastomeric polymer.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Bostik, Inc.; Durabond D-222 Duraguard Membrane or Hydroment Gold.
b. C-Cure; CureLastic 949 or Pro-Red Waterproofing Membrane 963.
c. Custom Building Products; Redgard Waterproofing and Crack Prevention Membrane or FractureFree Crack Prevention Membrane or Semco Crack Prevention Membrane.
d. Jamo Inc.; Waterproof.
e. Mer-Kote Products, Inc.; Fracture-Guard 5000.
f. Southern Grouts & Mortars, Inc.; Southcrete 1100 Crack Suppression and Waterproofing.
g. TEC, a subsidiary of H. B. Fuller Company; HydraFlex - Waterproofing Crack Isolation Membrane.

I. Latex-Portland Cement: Flexible mortar consisting of cement-based mix and latex additive.
1. Products: Subject to compliance with requirements, provide one of the following:
a. C-Cure; UltraCure 971.
b. MAPEI Corporation; Mapelastic (PRP 315).
c. TEC, a subsidiary of H. B. Fuller Company; Triple Flex Waterproofing, Crack Isolation Membrane & Mortar.

J. Urethane Crack Isolation Membrane and Tile-Setting Adhesive: One-part, liquid-applied urethane, with a VOC content of 65 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24),, that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," in a consistency suitable for trowel application and intended for use as both waterproofing and tile-setting adhesive in a two-step process.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Bostik, Inc.; Durabond D-200 or Hydroment Ultra-Set or Hydroment Ultra-Set Advanced.

2.4 SETTING MATERIALS

A. Portland Cement Mortar (Thickset) Installation Materials: ANSI A108.02.
1. Cleavage Membrane: Asphalt felt, ASTM D 226, Type I (No. 15); or polyethylene sheeting, ASTM D 4397, 4.0 mils (0.1 mm) thick.
2. Reinforcing Wire Fabric: Galvanized, welded wire fabric, 2 by 2 inches (50.8 by 50.8 mm) by 0.062 inch (1.57 mm) in diameter; comply with ASTM A 185/A 185M and ASTM A 82/A 82M except for minimum wire size.
3. Latex Additive: Manufacturer's standard acrylic resin or styrene-butadiene-rubber water emulsion, serving as replacement for part or all of gaging water, of type specifically recommended by latex-additive manufacturer for use with field-mixed portland cement and aggregate mortar bed.

B. Dry-Set Portland Cement Mortar (Thin Set): ANSI A118.1.
1. For wall applications, provide mortar that complies with requirements for nonsagging mortar in addition to the other requirements in ANSI A118.1.

C. Latex-Portland Cement Mortar (Thin Set): ANSI A118.4.

1. Provide prepackaged, dry-mortar mix containing dry, redispersible, vinyl acetate or acrylic additive to which only water must be added at Project site.
2. Provide prepackaged, dry-mortar mix combined with acrylic resin or styrene-butadiene-rubber liquid-latex additive at Project site.
3. For wall applications, provide mortar that complies with requirements for nonsagging mortar in addition to the other requirements in ANSI A118.4.

D. Medium-Bed, Latex-Portland Cement Mortar: Comply with requirements in ANSI A118.4. Provide product that is approved by manufacturer for application thickness of 5/8 inch (16 mm).

E. Water-Cleanable, Tile-Setting Epoxy: ANSI A118.3, with a VOC content of 65 g/L or less when calculated according to 40 CFR 59, Subpart D.

F. Organic Adhesive: ANSI A136.1, Type I, with a VOC content of 65 g/L or less when calculated according to 40 CFR 59, Subpart D.

2.5 GROUT MATERIALS

A. Sand-Portland Cement Grout: ANSI A108.10, composed of white or gray cement and white or colored aggregate as required to produce color indicated.

B. Standard Cement Grout: ANSI A118.6.

C. Polymer-Modified Tile Grout: ANSI A118.7.

D. Water-Cleanable Epoxy Grout: ANSI A118.3, with a VOC content of 65 g/L or less when calculated according to 40 CFR 59, Subpart D.

2.6 ELASTOMERIC SEALANTS

A. General: Provide sealants, primers, backer rods, and other sealant accessories that comply with the following requirements and with the applicable requirements in Division 07 Section "Joint Sealants" and that do not stain stone.
1. Sealants shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D.
2. Use primers, backer rods, and sealant accessories recommended by sealant manufacturer.

B. Colors: Provide colors of exposed sealants to match colors of grout in stone tile adjoining sealed joints unless otherwise indicated.

C. One-Part, Mildew-Resistant Silicone Sealant: ASTM C 920; Type S; Grade NS; Class 25; Uses NT, G, A, and, as applicable to nonporous joint substrates indicated, O; formulated with fungicide, intended for sealing interior stone tile joints and other nonporous substrates that are subject to in-service exposures of high humidity and extreme temperatures.

D. Multipart, Pourable Urethane Sealant for Use T: ASTM C 920; Type M; Grade P; Class 25; Uses T, M, A, and, as applicable to joint substrates indicated, O.

2.7 MISCELLANEOUS MATERIALS

A. Trowelable Patching Compounds: Latex-modified, portland cement-based formulation provided or approved by manufacturer of tile-setting materials for installations indicated.

B. Metal Edge Strips: Angle or L-shaped, height to match stone tile and setting-bed thickness, metallic or combination of metal and PVC or neoprene base, designed specifically for flooring applications; stainless-steel, ASTM A 666, 300 Series exposed-edge material.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Blanke Corporation.
      b. Ceramic Tool Company, Inc.
      c. Schluter Systems L.P.

C. Protective Coating: Liquid grout-release coating that is formulated to protect exposed surfaces of stone tile against adherence of mortar and grout; compatible with stone, mortar, and grout products; easily removable after grouting is completed without damaging grout or stone tile; and recommended for use as temporary protective coating for stone tile.
   1. Floor sealer complying with "Floor Sealer" Paragraph below may be used provided it is recommended by manufacturer for use as a grout release.

D. Cleaner: A neutral cleaner capable of removing soil and residue without harming stone tile and grout surfaces, specifically approved for materials and installations indicated by stone tile producers and grout manufacturers.

E. Floor Sealer: Colorless, stain- and slip-resistant sealer, not affecting color or physical properties of stone surfaces as recommended by stone tile producers for application indicated.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Bostik, Inc.
      b. Custom Building Products.
      c. Hillyard, Inc.
      d. HMK Stone Care System.
      e. Summitville Tiles, Inc.

2.8 FABRICATION

A. Facial Dimensions of Stone Tiles with Polished or Honed Faces: Do not vary facial dimensions from specified dimensions by more than plus or minus 1/64 inch.

B. Thickness of Stone Tiles with Polished, Honed, or Sand-Rubbed Finish: Do not vary from specified thickness by more than plus or minus 1/32 inch.

C. Joint Surfaces: Except for specified beveled or eased edges if any, dress joint surfaces square for full depth of stone tile.

D. Backs of Pieces: Gage units by dressing backs of pieces smooth and flat. When tested with a 24-inch straightedge, gap shall not exceed 1/32 inch.
   1. Natural-cleft stone need not be gaged if gap does not exceed 1/16 inch when tested with a 24-inch straightedge on backs of units.

E. Thresholds: Fabricate to size and profile as indicated or required to provide transition between adjacent floor finishes.
   1. Bevel edges of thresholds at 1:2 slope, aligning lower edge of bevel with adjacent floor finish. Limit height of bevel to 1/2 inch or less, and finish bevel to match face of threshold.

2.9 MIXING MORTARS AND GROUT

A. Mix mortars and grouts to comply with referenced standards and with mortar and grout manufacturers' written instructions.

B. Add materials, water, and additives in accurate proportions.

C. Use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions where stone tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of installed stone tile.
   1. Verify that substrates for setting stone tile are firm, dry, clean, and free of coatings that are incompatible with tile-setting materials including curing compounds and other substances that contain soap, wax, oil, or silicone, and that they comply with flatness tolerances required by ANSI A108.01 for installations indicated.
   2. Verify that concrete substrates for stone tile floors installed with bonded mortar bed or thin-set mortar comply with surface finish requirements in ANSI A108.01 for installations indicated.
      a. Verify that surfaces that received a steel trowel finish have been mechanically scarified.
      b. Verify that protrusions, bumps, and ridges have been removed by sanding or grinding.
   3. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind stone tile has been completed.
   4. Verify that joints and cracks in stone tile substrates are coordinated with stone tile joint locations; if not coordinated, adjust joint locations in consultation with Architect.

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

3.2 PREPARATION

A. Fill cracks, holes, and depressions in concrete substrates for stone tile floors installed with adhesives or thin-set mortar with trowelable patching compound specifically recommended by tile-setting material manufacturer.

B. Where indicated, prepare substrates to receive waterproofing by applying a reinforced mortar bed that complies with ANSI A108.1A and is sloped 1/4 inch per foot (1:50) toward drains.

C. Lay out stone tile patterns by marking joint lines on substrates to verify joint placement at edges, corners, doors, and other critical elements.
   1. Notify Architect seven days in advance of dates and times when layout will be done.
   2. Obtain Architect's approval of layout before starting stone tile installation.

D. Lay out stone tiles on substrates or on an adjacent surface to establish placement of individual stone tiles for balance of color and pattern variations.
   1. Notify Architect seven days in advance of dates and times when layout will be done.
   2. Architect may relocate specific stone tiles with other stone tiles of same type and will determine final location of each stone tile within indicated patterns.
   3. Identify each stone tile with a temporary number marked on face of stone tile that corresponds with an identical number marked on a layout drawing, and obtain Architect's approval before starting stone tile installation.

E. Field-Applied Temporary Protective Coating: If indicated under stone tile type or needed to prevent grout from staining or adhering to exposed stone tile surfaces, precoat them with continuous film of temporary protective coating, taking care not to coat unexposed stone tile surfaces.

3.3 STONE TILE INSTALLATION

A. Comply with TCA's "Handbook for Ceramic Tile Installation" for TCA installation methods specified in stone tile installation schedules. Comply with parts of the ANSI A108 Series "Specifications for Installation of Ceramic Tile" that are referenced in TCA installation methods specified in stone tile installation schedules, and apply to types of setting and grouting materials used.
   1. For the following installations, follow procedures in the ANSI A108 Series of tile installation standards for providing 95 percent mortar coverage:
      a. Exterior stone tile floors.
      b. Stone tile floors in wet areas.
      c. Stone tile floors composed of stone tiles 8 by 8 inches or larger.

B. Wipe backs of stone tiles with a damp cloth to remove dirt and dust before units are installed.

C. Extend stone tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.

D. Accurately form intersections and returns. Perform cutting and drilling of stone tile without marring visible surfaces. Carefully grind cut edges of stone tile abutting trim, finish, or built-in items for straight aligned joints. Fit stone tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap stone tile.

E. Finish cut stone tile edges that will not be concealed by other construction by grinding and honing cut surfaces and easing edges to match factory-fabricated edges unless otherwise indicated.

F. Jointing Pattern: Lay stone tile in grid pattern unless otherwise indicated. Lay out stone tile work and center stone tile fields in both directions in each space or on each wall area. Lay out stone tile work to minimize the use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated.
   1. Where adjoining stone tiles on floor, base, walls, or trim are specified or indicated to be same size, align joints.

G. Lay out stone tile wainscots to dimensions indicated or to next full tile beyond dimensions indicated.

H. Match stone tiles within each space by selecting tiles to achieve uniformity of color and pattern. Reject or relocate stone tiles that do not match color and pattern of adjacent tiles.

I. Mix stone tiles to achieve a uniformly random distribution of color shadings and patterns.

J. Pattern Orientation: For stone varieties with directional pattern, orient pattern as directed by Architect.

K. Expansion Joints: Provide expansion joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated. Form joints during installation of setting materials, mortar beds, and stone tile. Do not saw-cut joints after installing stone tiles.
   1. Where joints occur in concrete substrates, locate joints in stone tile surfaces directly above them.
   2. Prepare joints and apply sealants to comply with requirements in Division 07 Section "Joint Sealants."

L. Stone Thresholds: Install stone thresholds in same type of setting bed as adjacent floor unless otherwise indicated.

1. At locations where mortar bed (thickset) would otherwise be exposed above adjacent floor finishes, set thresholds in latex-portland cement mortar (thin set).
2. Do not extend cleavage membrane, waterproofing, or crack isolation membrane under thresholds set in dry-set portland cement or latex-portland cement mortar. Fill joints between such thresholds and adjoining stone tile set on cleavage membrane, waterproofing, or crack isolation membrane with elastomeric sealant.

M. Metal Edge Strips: Install where exposed edge of stone tile flooring meets carpet, wood, or other flooring that finishes flush with or below top of stone tile and no threshold is indicated.

3.4 WATERPROOFING INSTALLATION

A. Install waterproofing to comply with ANSI A108.13 and manufacturer's written instructions to produce waterproof membrane of uniform thickness and bonded securely to substrate.

B. Do not install tile or setting materials over waterproofing until waterproofing has cured and been tested to determine that it is watertight.

3.5 CRACK ISOLATION MEMBRANE INSTALLATION

A. Install crack isolation membrane to comply with ANSI A108.17 and manufacturer's written instructions to produce membrane of uniform thickness and bonded securely to substrate.

B. Do not install tile or setting materials over crack isolation membrane until membrane has cured.

3.6 INSTALLATION TOLERANCES

A. Variation from Plumb: For vertical joints, external corners, and other conspicuous lines, do not exceed 1/8 inch in 8 feet .

B. Variation in Level: For horizontal joints and other conspicuous lines, do not exceed 1/8 inch in 10 feet, or 1/2 inch maximum.

C. Variation in Surface Plane of Flooring: Do not exceed 1/8 inch in 10 feet from level or slope indicated when tested with a 10-foot straightedge.

D. Variation in Plane between Adjacent Units (Lipping): Do not exceed the following differences between faces of adjacent units as measured from a straightedge parallel to stone tiled surface:
1. Units with Polished Faces: 1/64 inch.
2. Units with Honed Faces: 1/64 inch.
3. Units with Natural-Cleft Faces: Depth of natural-cleft finish or 3/16 inch, whichever is less.

E. Variation in Joint Width: Do not vary joint thickness more than 1/16 inch or one-fourth of nominal joint width, whichever is less.

F. Hand-Tight Joints: Do not exceed 1/32 inch.

3.7 ADJUSTING AND CLEANING

A. Remove and replace material that is stained or otherwise damaged or that does not match adjoining stone tile. Provide new matching units, installed as specified and in a manner to eliminate evidence of replacement.

B. Cleaning: On completion of placement and grouting, clean stone tile surfaces so they are free of foreign matter.

1. Remove epoxy and latex-portland cement grout residue from stone tile as soon as possible.
2. Clean grout smears and haze from stone tile according to stone tile and grout manufacturer's written instructions but no sooner than 10 days after installation. Use only cleaners recommended by stone tile and grout manufacturers and only after determining that cleaners are safe to use by testing on samples of stone tile and other surfaces to be cleaned. Protect metal surfaces and plumbing fixtures from effects of cleaning. Flush surfaces with clean water before and after cleaning.
3. Remove temporary protective coating by method recommended by coating manufacturer and acceptable to stone tile and grout manufacturer. Trap and remove coating to prevent drain clogging. Do not remove floor sealer if used as protective coating.

C. Apply sealer to cleaned stone tile flooring according to sealer manufacturer's written instructions.

3.8 PROTECTION

A. Protect installed stone tile floors with kraft paper or other heavy covering during construction period to prevent staining, damage, and wear. If recommended by stone tile manufacturer, apply coat of neutral protective cleaner to completed stone tile walls and floors.

B. Prohibit foot and wheel traffic from stone tiled floors for at least seven days after grouting is completed.

C. Before final inspection, remove protective coverings and rinse neutral protective cleaner from stone tile surfaces.

END OF SECTION

SECTION 09 51 13

ACOUSTICAL PANEL CEILINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes acoustical panels and exposed suspension systems for ceilings.

B. Related Requirements:
1. Section 09 51 33 "Acoustical Metal Pan Ceilings."

C. Products furnished, but not installed under this Section, include anchors, clips, and other ceiling attachment devices to be cast in concrete.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:
1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
   a. Include statement indicating cost for each product having recycled content.
2. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
3. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

C. Samples: For each exposed product and for each color and texture specified, 6 inches in size.

D. Samples for Initial Selection: For components with factory-applied color finishes.

E. Samples for Verification: For each component indicated and for each exposed finish required, prepared on Samples of size indicated below.
1. Acoustical Panel: Set of full-size Samples of each type, color, pattern, and texture.
2. Exposed Suspension-System Members, Moldings, and Trim: Set of 6-inch- long Samples of each type, finish, and color.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which suspension systems will be attached.
   3. Size and location of initial access modules for acoustical panels.
   4. Items penetrating finished ceiling including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
   5. Perimeter moldings.

B. Qualification Data: For testing agency.

C. Product Test Reports: For each acoustical panel ceiling, for tests performed by manufacturer and witnessed by a qualified testing agency.

D. Evaluation Reports: For each acoustical panel ceiling suspension system and anchor and fastener type, from ICC-ES.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For finishes to include in maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Acoustical Ceiling Panels: Full-size panels equal to 2 percent of quantity installed.
   2. Suspension-System Components: Quantity of each exposed component equal to 2 percent of quantity installed.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to NVLAP for testing indicated.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver acoustical panels, suspension-system components, and accessories to Project site in original, unopened packages and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.

B. Before installing acoustical panels, permit them to reach room temperature and a stabilized moisture content.

C. Handle acoustical panels carefully to avoid chipping edges or damaging units in any way.

1.10 FIELD CONDITIONS

A. Environmental Limitations: Do not install acoustical panel ceilings until spaces are enclosed and weatherproof, wet work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.
   1. Pressurized Plenums: Operate ventilation system for not less than 48 hours before beginning acoustical panel ceiling installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: Comply with ASTM E 1264 for Class A materials.
   2. Smoke-Developed Index: 450 or less.

B. Fire-Resistance Ratings: Comply with ASTM E 119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.

2.2 ACOUSTICAL PANELS, GENERAL

A. Source Limitations:
   1. Acoustical Ceiling Panel: Obtain each type from single source from single manufacturer.
   2. Suspension System: Obtain each type from single source from single manufacturer.

B. Source Limitations: Obtain each type of acoustical ceiling panel and supporting suspension system from single source from single manufacturer.

C. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

D. Glass-Fiber-Based Panels: Made with binder containing no urea formaldehyde.

E. Acoustical Panel Standard: Provide manufacturer's standard panels of configuration indicated that comply with ASTM E 1264 classifications as designated by types, patterns, acoustical ratings, and light reflectances unless otherwise indicated.
   1. Mounting Method for Measuring NRC: Type E-400; plenum mounting in which face of test specimen is 15-3/4 inches away from test surface according to ASTM E 795.

F. Acoustical Panel Colors and Patterns: Match appearance characteristics indicated for each product type.
   1. Where appearance characteristics of acoustical panels are indicated by referencing pattern designations in ASTM E 1264 and not manufacturers' proprietary product designations, provide products selected by Architect from each manufacturer's full range that comply with requirements indicated for type, pattern, color, light reflectance, acoustical performance, edge detail, and size.

2.3 ACOUSTICAL PANELS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product manufactured in the United States by one of the following:
   1. Armstrong World Industries, Inc.
   2. CertainTeed Corp.
   3. Chicago Metallic Corporation.
   4. USG Interiors, Inc.; Subsidiary of USG Corporation.

Basis of Design

ACT-1

MANUF:	USG
GRID STYLE:	9/16" DONN DXFF FL WITH 1/8" REVEAL
GRID COLOR:	WHITE
TILE STYLE:	HALCYON CLIMAPLUS
TILE NRC:	0.095 MIN.
TILE SIZE:	24"X24"
TILE COLOR:	WHITE
TILE FINISH:	SMOOTH

ACT-2

MANUF:	USG
GRID STYLE:	15/16" DONN CE
GRID COLOR:	WHITE
TILE STYLE:	CLEAN ROOM CLIMAPLUS CLASS 100 PANELS
TILE NRC:	N/A; UNPERFORATED
TILE SIZE:	24"X24"
TILE COLOR:	WHITE
TILE FINISH:	SMOOTH

ACT-3

MANUF:	USG
GRID STYLE:	15/16" DONN DX/DXL EXPOSED TEE
GRID COLOR:	WHITE
TILE STYLE:	ECLIPSE CLIMAPLUS
TILE NRC:	0.070 MIN.
TILE SIZE:	24"X24"
TILE COLOR:	WHITE
TILE FINISH:	SMOOTH

B. Classification: Provide fire-resistance-rated panels complying with ASTM E 1264 for type, form, and pattern as follows:
   1. Type and Form: Type IV, mineral base with membrane-faced overlay; Form 2, water felted; with vinyl overlay on face .
   2. Type and Form: Type XX, other types; described as high-density, ceramic- and mineral-base panels with scrubbable finish, resistant to heat, moisture, and corrosive fumes.
   3. Pattern: As indicated by manufacturer's designation .

C. Broad Spectrum Antimicrobial Fungicide and Bactericide Treatment: Provide acoustical panels treated with manufacturer's standard antimicrobial formulation that inhibits fungus, mold, mildew, and gram-positive and gram-negative bacteria and showing no mold, mildew, or bacterial growth when tested according to ASTM D 3273 and evaluated according to ASTM D 3274 or ASTM G 21.

2.4 METAL SUSPENSION SYSTEMS, GENERAL

A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Metal Suspension-System Standard: Provide manufacturer's standard direct-hung metal suspension systems of types, structural classifications, and finishes indicated that comply with applicable requirements in ASTM C 635/C 635M.
   1. High-Humidity Finish: Comply with ASTM C 635/C 635M requirements for "Coating Classification for Severe Environment Performance" where high-humidity finishes are indicated.

C. Attachment Devices: Size for five times the design load indicated in ASTM C 635/C 635M, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.
   1. Anchors in Concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing according to ASTM E 488 or ASTM E 1512 as applicable, conducted by a qualified testing and inspecting agency.
      a. Type: Postinstalled expansion Postinstalled bonded anchors.
      b. Corrosion Protection: Stainless-steel components complying with ASTM F 593 and ASTM F 594, Group 1 Alloy 304 or 316 for bolts; Alloy 304 or 316 for anchor.
      c. Corrosion Protection: Components fabricated from nickel-copper-alloy rods complying with ASTM B 164 for UNS No. N04400 alloy.

D. Wire Hangers, Braces, and Ties: Provide wires complying with the following requirements:
   1. Stainless-Steel Wire: ASTM A 580/A 580M, Type 304, nonmagnetic.
   2. Nickel-Copper-Alloy Wire: ASTM B 164, nickel-copper-alloy UNS No. N04400.
   3. Size: Select wire diameter so its stress at three times hanger design load (ASTM C 635/C 635M, Table 1, "Direct Hung") will be less than yield stress of wire, but provide not less than 0.135-inch-diameter wire.

E. Hanger Rods Flat Hangers: Mild steel, zinc coated or protected with rust-inhibitive paint.

F. Angle Hangers: Angles with legs not less than 7/8 inch wide; formed with 0.04-inch- thick, galvanized-steel sheet complying with ASTM A 653/A 653M, G90 coating designation; with bolted connections and 5/16-inch- diameter bolts.

G. Clean-Room Gasket System: Where indicated, provide manufacturer's standard system, including manufacturer's standard antimicrobial gasket and related adhesives, tapes, seals, and retention clips, designed to seal out foreign material from and maintain positive pressure in clean room.

2.5 METAL SUSPENSION SYSTEM

A. Basis-of-Design Product: Subject to compliance with requirements, provide Donn Suspension system by USG Interiors, Inc.; Subsidiary of USG Corporation or comparable product by one of the following:
   1. Armstrong World Industries, Inc.
   2. CertainTeed Corp.
   3. Chicago Metallic Corporation.

2.6 METAL EDGE MOLDINGS AND TRIM

A. Roll-Formed, Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that comply with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for exposed flanges of suspension-system runners.
   1. Provide manufacturer's standard edge moldings that fit acoustical panel edge details and suspension systems indicated and that match width and configuration of exposed runners unless otherwise indicated.
   2. For lay-in panels with reveal edge details, provide stepped edge molding that forms reveal of same depth and width as that formed between edge of panel and flange at exposed suspension member.

2.7 ACOUSTICAL SEALANT

A. Products: Subject to compliance with requirements, provide one of the following:
   1. Acoustical Sealant for Exposed and Concealed Joints:
      a. Acoustical Sealant for Concealed Joints:
      b. Henkel Corporation; OSI Pro-Series SC-175 Acoustical Sound Sealant.
      c. Pecora Corporation; AIS-919.
      d. Tremco, Inc.; Tremco Acoustical Sealant.

B. Acoustical Sealant: Manufacturer's standard sealant complying with ASTM C 834 and effective in reducing airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.
   1. Exposed and Concealed Joints: Non-sag, paintable, non-staining latex sealant.
   2. Concealed Joints: Nondrying, non-hardening, non-skinning, non-staining, gunnable, synthetic-rubber sealant.
   3. Acoustical sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, including structural framing to which acoustical panel ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of acoustical panel ceilings.

B. Examine acoustical panels before installation. Reject acoustical panels that are wet, moisture damaged, or mold damaged.

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

3.2 PREPARATION

A. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders, and comply with layout shown on reflected ceiling plans.

3.3 INSTALLATION

A. General: Install acoustical panel ceilings to comply with ASTM C 636/C 636M and seismic design requirements indicated, according to manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."
   1. Fire-Rated Assembly: Install fire-rated ceiling systems according to tested fire-rated design.

B. Suspend ceiling hangers from building's structural members and as follows:
   1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
   2. Splay hangers only where required and, if permitted with fire-resistance-rated ceilings, to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
   3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension-system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
   4. Secure wire hangers to ceiling-suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
   5. Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both the structure to which hangers are attached and the type of hanger involved. Install hangers in a manner that will not cause them to deteriorate or fail due to age, corrosion, or elevated temperatures.
   6. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, post-installed mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
   7. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
   8. Do not attach hangers to steel deck tabs.
   9. Do not attach hangers to steel roof deck. Attach hangers to structural members.
   10. Space hangers not more than 48 inches o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches from ends of each member.
   11. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.

C. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers, without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or post-installed anchors.

D. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.
   1. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
   2. Screw attach moldings to substrate at intervals not more than 16 inches o.c. and not more than 3 inches from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet. Miter corners accurately and connect securely.
   3. Do not use exposed fasteners, including pop rivets, on moldings and trim.

E. Install suspension-system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.

F. Install acoustical panels with undamaged edges and fit accurately into suspension-system runners and edge

moldings. Scribe and cut panels at borders and penetrations to provide a neat, precise fit.

1. Arrange directionally patterned acoustical panels as follows:
   a. As indicated on reflected ceiling plans.
   b. Install panels with pattern running in one direction parallel to long axis of space.
   c. Install panels in a basket-weave pattern.
2. For square-edged panels, install panels with edges fully hidden from view by flanges of suspension-system runners and moldings.
3. For reveal-edged panels on suspension-system runners, install panels with bottom of reveal in firm contact with top surface of runner flanges.
4. For reveal-edged panels on suspension-system members with box-shaped flanges, install panels with reveal surfaces in firm contact with suspension-system surfaces and panel faces flush with bottom face of runners.
5. Paint cut edges of panel remaining exposed after installation; match color of exposed panel surfaces using coating recommended in writing for this purpose by acoustical panel manufacturer.
6. Install clean-room gasket system in areas indicated, sealing each panel and fixture as recommended by panel manufacturer's written instructions.
7. Protect lighting fixtures and air ducts to comply with requirements indicated for fire-resistance-rated assembly.

3.4 FIELD QUALITY CONTROL

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

B. Perform the following tests and inspections of completed installations of acoustical panel ceiling hangers and anchors and fasteners in successive stages. Do not proceed with installations of acoustical panel ceiling hangers for the next area until test results for previously completed installations show compliance with requirements.
   1. Extent of Each Test Area: When installation of ceiling suspension systems on each floor has reached 20 percent completion but no panels have been installed.
      a. Within each test area, testing agency will select one of every 10 power-actuated fasteners and post-installed anchors used to attach hangers to concrete and will test them for 200 lbf of tension; it will also select one of every two post-installed anchors used to attach bracing wires to concrete and will test them for 440 lbf of tension.
      b. When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those anchors not previously tested until 20 pass consecutively and then will resume initial testing frequency.

C. Acoustical panel ceiling hangers and anchors and fasteners will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 CLEANING

A. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension-system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION

SECTION 09 51 33

ACOUSTICAL METAL PAN CEILINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes lay-in acoustical metal pans and the following suspension system for ceilings:
   1. Direct hung, exposed tee grid.

B. Related Sections:
   1. Section 09 51 13 "Acoustical Panel Ceilings" for ceilings consisting of mineral-base and glass-fiber-base acoustical panels and exposed suspension systems.

1.3 DEFINITIONS

A. CAC: Ceiling Attenuation Class.

B. LR: Light Reflectance coefficient.

C. NRC: Noise Reduction Coefficient.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Exterior snap-in metal pan ceilings shall withstand exterior exposure and the effects of gravity loads and the following loads and stresses without showing permanent deformation of ceiling system components including pans and suspension system; noise or metal fatigue caused by vibration, deflection, and displacement of ceiling units; or permanent damage to fasteners and anchors.

B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
   1. Temperature Change (Range): 100 deg F.

1.5 ACTION SUBMITTALS

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

B. LEED Submittals:
   1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
      a. Include statement indicating cost for each product having recycled content.
   2. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.

3. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

C. Samples for Initial Selection: For components with factory-applied color and other decorative finishes.

D. Samples for Verification: For each component indicated and for each exposed finish required, prepared on Samples of size indicated below:
1. Metal Pans: Set of full-size Samples of each type, finish, color, pattern, and texture. Show pan edge profile.
2. Exposed Suspension System Members, Moldings and Trim: Set of 12-inch- long Samples of each type, finish, and color.
3. Sound Absorber: Match size of Sample metal pan.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
1. Ceiling suspension members.
2. Method of attaching hangers to building structure.
   a. Furnish layouts for cast-in-place anchors, clips, and other ceiling attachment devices whose installation is specified in other Sections.
3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
4. Ceiling perimeter and penetrations through the ceiling; and trim and moldings.
5. Minimum Drawing Scale: 1/4 inch = 1 foot.

B. Qualification Data: For testing agency.

C. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each acoustical metal pan ceiling.

D. Evaluation Reports: For each acoustical metal pan ceiling and components and anchor and fastener type.

E. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For finishes to include in maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Acoustical Metal Pans: Full-size units equal to 2 percent of quantity installed.
2. Suspension System Components: Quantity of each grid and exposed molding and trim equal to 2 percent of quantity installed.
3. Hold-Down Clips: Equal to 2 percent of quantity installed.

1.9 QUALITY ASSURANCE

A. Acoustical Testing Agency Qualifications: An independent testing laboratory or an NVLAP-accredited laboratory, with the experience and capability to conduct the testing indicated. NVLAP-accredited laboratories must document accreditation, based on a "Certificate of Accreditation" and a "Scope of Accreditation" listing the test methods specified.

B. Source Limitations:
   1. Acoustical Ceiling Pans: Obtain each type from single source from single manufacturer.
   2. Suspension Systems: Obtain each type from single source from single manufacturer.

C. Source Limitations for Acoustical Metal Pan Ceilings: Obtain each combination of acoustical metal pans and exposed suspension systems from one source with resources to provide products of consistent quality in appearance, physical properties, and performance.

D. Surface-Burning Characteristics: Complying with ASTM E 1264 for Class A materials as determined by testing identical products according to ASTM E 84 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.

E. Seismic Standard: Provide acoustical metal pan ceilings designed and installed to withstand the effects of earthquake motions according to the following:
   1. Standard for Ceiling Suspension Systems Requiring Seismic Restraint: Comply with ASTM E 580.
   2. CISCA's Recommendations for Acoustical Ceilings: Comply with CISCA's "Recommendations for Direct-Hung Acoustical Tile and Lay-in Panel Ceilings - Seismic Zones 0-2."
   3. CISCA's Guidelines for Systems Requiring Seismic Restraint: Comply with CISCA's "Guidelines for Seismic Restraint of Direct-Hung Suspended Ceiling Assemblies - Seismic Zones 3 & 4."
   4. UBC Standard 25-2, "Metal Suspension Systems for Acoustical Tile and for Lay-in Panel Ceilings."
   5. SEI/ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."

F. Preinstallation Conference: Conduct conference at Project site.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver acoustical metal pans, suspension system components, and accessories to Project site in original, unopened packages and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.

B. Handle acoustical metal pans, suspension system components, and accessories carefully to avoid damaging units and finishes in any way.

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Do not install acoustical metal pan ceilings until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

1.12 COORDINATION

A. Coordinate layout and installation of acoustical metal pans and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 ACOUSTICAL METAL CEILING PANS

A. Low-Emitting Materials: Acoustical metal pan ceilings shall comply with the testing and product

requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Acoustical Metal Pan Standard: Provide manufacturer's standard acoustical metal pans of configuration indicated that comply with ASTM E 1264 classifications as designated by types, acoustical ratings, and light reflectances unless otherwise indicated.
   1. Mounting Method for Measuring NRC: Type E-400; plenum mounting in which face of test specimen is 15-3/4 inches away from test surface per ASTM E 795.

C. Sheet Metal Characteristics: For metal components exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, roughness, stains, or discolorations.
   1. Aluminum Sheet: Roll-formed aluminum sheet, complying with ASTM B 209; alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.
   2. Steel Sheet: Commercial-quality, cold-rolled, carbon-steel sheet; stretcher leveled; with protective coating complying with ASTM C 635.
      a. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
      b. Painted Finishes: Electrolytic zinc-coated steel complying with ASTM A 591/A 591M, 40Z coating, surface treatment as recommended by finish manufacturer for type of use and finish indicated.
      c. Chemical/Mechanical Finishes: Uncoated steel sheet complying with ASTM A 1008/A 1008M with luster or bright finish as required by finisher for applying electroplating or other metallic-finishing processes.
   3. Stainless-Steel Sheet: Complying with ASTM A 240/A 240M, Type 430.

D. Sound-Absorbent Fabric Layer: Provide fabric layer, sized to fit concealed surface of pan, and consisting of black, nonwoven, nonflammable, sound-absorbent material with surface-burning characteristics for flame-spread index of 25 or less and smoke-developed index of 50 or less, as determined by testing per ASTM E 84.
   1. Bond fabric layer to panels in the factory with manufacturer's standard nonflammable adhesive.

E. Sound-Absorbent Pads: Provide width and length to completely fill concealed surface of pan, with surface-burning characteristics for flame-spread index of 25 or less and smoke-developed index of 50 or less, as determined by testing per ASTM E 84, and to comply with the following requirements:
   1. Plastic Sheet-Wrapped Mineral-Fiber Insulation: Pads consisting of nonrigid, PVC plastic sheet encapsulating unfaced mineral-fiber insulation complying with ASTM C 553, Type I, II, or III, and as follows:
      a. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent by weight.
      b. Mineral-Fiber Type and Thickness: Glass fiber; 3 inches.
      c. Mineral-Fiber Density: 1 lb/cu. ft..
      d. Plastic Sheet Thickness and Color: Not less than 0.003 inch; clear.
   2. Unwrapped, Glass-Fiber Insulation: Black coated, unfaced, complying with ASTM C 553, Type I, II, or III; not less than 1-lb/cu. ft. density; treated to be nondusting; and as follows:
      a. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent by weight.
      b. Thickness: 1-1/2 inches.
   3. Spacer Grids: Provide manufacturer's standard aluminum or galvanized-steel grid units that provide an air cushion between metal pans and insulation pads and that act to improve sound absorption.

2.2 STEEL PANS FOR ACOUSTICAL METAL PAN CEILING

A. Steel Pans:

1. Basis-of-Design Product: Subject to compliance with requirements, provide MetalWorks by Armstrong World Industries, Inc. or a comparable product by one of the following:
   a. American Decorative Ceilings
   b. Ceilings Plus
   c. Chicago Metallic Corporation
   d. Hunter Douglas Architectural Products, Inc.
   e. Simplex Ceilings, a division of Intalite Inc.
   f. Steel Ceilings Inc.
   g. USG Interiors, Inc.

B. Classification: Units complying with ASTM E 1264 for Type V, perforated steel facing (pan) with mineral or glass fiber-base backing.
   1. Pattern: Pattern C (perforated, small holes) regularly spaced, with uniform perforations of dimension, holes per square foot or inch, and percent open area as specified by product designation.

C. Pan Edge Detail: Manufacturer's standard edge detail.

D. Pan Joint Detail: Flush narrow reveal, not greater than 9/16 inch wide.

E. Pan Size: 24 by 24 inches .

F. Pan Face Finish: Painted in color selected from manufacturer's full range.

2.3 DIRECT-HUNG, STANDARD-GRID, METAL SUSPENSION SYSTEM FOR ACOUSTICAL METAL PAN CEILING

Basis of Design
ACT-4

Manuf:	Armstrong
Grid Style:	Suprafine Xl 9/16" Exposed Tee
Grid Color:	Silver Grey
Tile Style:	Metalworks, 9/16" Square Tegular, Smooth Texture, Securelock Microperforated (P4)
Tile NRC:	.070 Min.
Tile Size:	24"X24"

A. Tile Color: Silver Grey Suspension System: For clip-in pans.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Suprafine X1 by Armstrong World industries, Inc. or a comparable product by one of the following:
      a. BPB USA.
      b. Chicago Metallic Corporation.
      c. USG Interiors, Inc..

B. Narrow-Face, Capped, Double-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet, prepainted, electrolytic zinc-coated or hot-dip galvanized according to ASTM A 653/653M, G30 coating designation, with prefinished, cold-rolled, 9/16-inch- wide sheet metal caps on flanges.
   1. Structural Classification: Heavy-duty system.
   2. Cap Material: Steel or aluminum cold-rolled sheet.
   3. Cap Finish: Painted in color as selected from manufacturer's full range.

C. Suspension System for Torsion-Spring Metal Pans: Provide runners with factory-cut slots fabricated to accept torsion-spring attachment.

2.4 ACOUSTICAL SEALANT

A. Acoustical Sealant for Exposed and Concealed Joints: Manufacturer's standard nonsag, paintable, nonstaining latex sealant, with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), complying with ASTM C 834 and effective in reducing airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Pecora Corporation; AC-20 FTR Acoustical and Insulation Sealant.
      b. USG Corporation; SHEETROCK Acoustical Sealant.

B. Acoustical Sealant for Concealed Joints: Manufacturer's standard nondrying, nonhardening, nonskinning, nonstaining, gunnable, synthetic-rubber sealant, with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), recommended for sealing interior concealed joints to reduce airborne sound transmission.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. OSI Sealants, Inc.; Pro-Series SC-175 Rubber Base Sound Sealant.
      b. Pecora Corporation; BA-98.
      c. Tremco, Inc.; Tremco Acoustical Sealant.

2.5 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. High-Humidity Finish: Comply with ASTM C 635 requirements for "Coating Classification for Severe Environment Performance" where high-humidity finishes are indicated.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 ALUMINUM FINISHES

A. Color-Coated Finish: Manufacturer's standard baked paint complying with coating manufacturer's written instructions for surface preparation, pretreatment, application, baking, and minimum dry film thickness.

2.7 GALVANIZED-STEEL SHEET FINISHES

A. Color-Coated Finish: Manufacturer's standard baked paint complying with coating manufacturer's written instructions for surface preparation, pretreatment, application, baking, and minimum dry film thickness.

2.8 STEEL SHEET FINISHES

A. Electroplated Finish: Electroplating process complying with finish manufacturer's written instructions for surface preparation, pretreatment, process, and minimum thickness to produce a coating uniform in appearance and free of blisters, pits, roughness, nodules, burning, cracks, unplated areas, and other visible defects.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, including structural framing to which acoustical metal pan ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of acoustical metal pan ceilings.

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

3.2 PREPARATION

A. Measure each ceiling area and establish layout of acoustical metal pans to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width pans at borders, and comply with layout shown on reflected ceiling plans and Coordination Drawings.

3.3 INSTALLATION

A. Install acoustical metal pan ceilings to comply with ASTM C 636 and seismic requirements indicated, per manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."

B. Suspend ceiling hangers from building's structural members and as follows:
1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
2. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
4. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
5. Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both structure to which hangers are attached and type of hanger involved.
6. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
7. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
8. Do not attach hangers to steel deck tabs.
9. Do not attach hangers to steel roof deck. Attach hangers to structural members.
10. Space hangers not more than 48 inches o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches from ends of each member.

11. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.

C. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers, without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or postinstalled anchors.

D. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical metal pans.
1. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
2. Screw attach moldings to substrate at intervals not more than 16 inches o.c. and not more than 3 inches from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet. Miter corners accurately and connect securely.
3. Do not use exposed fasteners, including pop rivets, on moldings and trim.

E. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.

F. Cut acoustical metal pan units for accurate fit at borders and at interruptions and penetrations by other work through ceilings. Stiffen edges of cut units as required to eliminate evidence of buckling or variations in flatness exceeding referenced standards for stretcher-leveled metal sheet.

G. Install acoustical metal pans in coordination with suspension system and exposed moldings and trim.
1. Align joints in adjacent courses to form uniform, straight joints parallel to room axis in both directions unless otherwise indicated.
2. Fit adjoining units to form flush, tight joints.
3. Install directionally patterned or textured metal pans in directions indicated.

H. Install hold-down clips where indicated.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
1. Suspended ceiling system.
2. Hangers, anchors, and fasteners.

B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

C. Tests and Inspections: Testing and inspecting of completed installations of acoustical panel ceiling hangers and anchors and fasteners shall take place in successive stages, in areas of extent and using methods as follows. Do not proceed with installations of acoustical panel ceiling hangers for the next area until test results for previously completed installations of acoustical panel ceiling hangers show compliance with requirements.
1. Extent of Each Test Area: When installation of ceiling suspension systems on each floor has reached 20 percent completion but no panels have been installed.
   a. Within each test area, testing agency will select 1 of every 10 power-actuated fasteners and postinstalled anchors used to attach hangers to concrete and will test them for 200 lbf of tension; it will also select one of every 2 postinstalled anchors used to attach bracing wires to concrete and will test them for 440 lbf of tension.

b. When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those anchors not previously tested until 20 pass consecutively and then will resume initial testing frequency.

D. Acoustical panel ceiling hangers and anchors and fasteners will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 CLEANING

A. Clean exposed surfaces of acoustical metal pan ceilings, including trim and edge moldings after removing strippable, temporary protective covering, if any. Comply with manufacturer's written instructions for stripping of temporary protective covering, cleaning, and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage, including dented and bent units.

END OF SECTION

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SECTION 09 65 13

RESILIENT BASE AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Resilient base.

B. Related Sections:
   1. Section 09 65 16 "Resilient Sheet Flooring" for resilient sheet floor coverings.
   2. Section 09 65 19 "Resilient Tile Flooring" for resilient floor tile.

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:
   1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

C. Samples for Initial Selection: For each type of product indicated.

D. Samples for Verification: For each type of product indicated, in manufacturer's standard-size Samples but not less than 12 inches long, of each resilient product color, texture, and pattern required.

E. Product Schedule: For resilient products. Use same designations indicated on Drawings.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Furnish not less than 10 linear feet for every 500 linear feet or fraction thereof, of each type, color, pattern, and size of resilient product installed.

1.5 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: As determined by testing identical products according to ASTM E 648 or NFPA 253 by a qualified testing agency.
   1. Critical Radiant Flux Classification: Class I, not less than 0.45 W/sq. cm.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store resilient products and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F or more than 90 deg F.

1.7 PROJECT CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F or more than 95 deg F, in spaces to receive resilient products during the following time periods:
   1. 48 hours before installation.
   2. During installation.
   3. 48 hours after installation.

B. Until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F or more than 95 deg F.

C. Install resilient products after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 RESILIENT BASE <RB>

A. Resilient Base:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allstate Rubber Corp.; Stoler Industries.
      b. Armstrong World Industries, Inc.
      c. Burke Mercer Flooring Products; Division of Burke Industries, Inc.
      d. Endura Rubber Flooring; Division of Burke Industries, Inc.
      e. Estrie Products International; American Biltrite (Canada) Ltd.
      f. Flexco, Inc.
      g. Johnsonite.
      h. Mondo Rubber International, Inc.
      i. Musson, R. C. Rubber Co.
      j. Nora Rubber Flooring; Freudenberg Building Systems, Inc.
      k. Roppe Corporation, USA.

B. Resilient Base Standard: ASTM F 1861.
   1. Material Requirement: Type TS (rubber, vulcanized thermoset) or Type TP (rubber, thermoplastic).
   2. Manufacturing Method: Group I (solid, homogeneous).
   3. Style: Cove (base with toe).

C. Minimum Thickness: 0.125 inch.

D. Height: 4 inches.

E. Lengths: Coils in manufacturer's standard length.

F. Outside Corners: Preformed .

G. Inside Corners: Preformed .

H. Finish: As selected by Architect from manufacturer's full range.

I. Colors and Patterns: As selected by Architect from full range of industry colors.

2.2 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement based or blended hydraulic-cement-based formulation provided or approved by manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by manufacturer to suit resilient products and substrate conditions indicated.
   1. Adhesives shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), except that adhesive for rubber stair treads shall have a VOC content of 60 g/L or less.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of resilient products.

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

3.2 PREPARATION

A. Prepare substrates according to manufacturer's written instructions to ensure adhesion of resilient products.

B. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound and remove bumps and ridges to produce a uniform and smooth substrate.

C. Do not install resilient products until they are same temperature as the space where they are to be installed.
   1. Move resilient products and installation materials into spaces where they will be installed at least 48 hours in advance of installation.

D. Sweep and vacuum clean substrates to be covered by resilient products immediately before installation.

3.3 RESILIENT BASE INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient base.

B. Apply resilient base to walls, columns, pilasters, casework and cabinets in toe spaces, and other permanent fixtures in rooms and areas where base is required.

C. Install resilient base in lengths as long as practicable without gaps at seams and with tops of adjacent pieces aligned.

D. Tightly adhere resilient base to substrate throughout length of each piece, with base in continuous contact with horizontal and vertical substrates.

E. Do not stretch resilient base during installation.

F. On masonry surfaces or other similar irregular substrates, fill voids along top edge of resilient base with manufacturer's recommended adhesive filler material.

G. Preformed Corners: Install preformed corners before installing straight pieces.

3.4 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protection of resilient products.

B. Perform the following operations immediately after completing resilient product installation:
   1. Remove adhesive and other blemishes from exposed surfaces.
   2. Damp-mop surfaces to remove marks and soil.

C. Protect resilient products from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

D. Cover resilient products until Substantial Completion.

END OF SECTION

SECTION 09 65 16

RESILIENT SHEET FLOORING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Rubber sheet floor covering, without backing.

B. Related Sections:
1. Section 09 65 13 "Resilient Base and Accessories" for resilient base, reducer strips, and other accessories installed with resilient floor coverings.
2. Section 09 65 19 "Resilient Tile Flooring" for resilient floor tile.

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:
1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
   a. Include statement indicating cost for each product having recycled content.
2. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
3. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
4. Product Data for Credit IEQ 4.3: For resilient sheet flooring, documentation from an independent testing agency indicating compliance with the FloorScore Standard.

C. Shop Drawings: For each type of floor covering. Include floor covering layouts, locations of seams, edges, columns, doorways, enclosing partitions, built-in furniture, cabinets, and cutouts.
1. Show details of special patterns.

D. Samples for Initial Selection: For each type of floor covering indicated.

E. Samples for Verification: In manufacturer's standard size, but not less than 6-by-9-inch sections of each different color and pattern of floor covering required.
1. For heat-welding bead, manufacturer's standard-size Samples, but not less than 9 inches long, of each color required.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each type of floor covering to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Floor Covering: Furnish quantity not less than 10 linear feet for every 500 linear feet or fraction thereof, in roll form and in full roll width for each color, pattern, and type of floor covering installed.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs workers for this Project who are competent in techniques required by manufacturer for floor covering installation and seaming method indicated.
   1. Engage an installer who employs workers for this Project who are trained or certified by floor covering manufacturer for installation techniques required.

B. Fire-Test-Response Characteristics: As determined by testing identical products according to ASTM E 648 or NFPA 253 by a qualified testing agency.
   1. Critical Radiant Flux Classification: Class I, not less than 0.45 W/sq. cm.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store floor coverings and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F or more than 90 deg F. Store rolls upright.

1.9 PROJECT CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F or more than 85 deg F, in spaces to receive floor coverings during the following time periods:
   1. 48 hours before installation.
   2. During installation.
   3. 48 hours after installation.

B. Until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F or more than 95 deg F.

C. Close spaces to traffic during floor covering installation.

D. Close spaces to traffic for 48 hours after floor covering installation.

E. Install floor coverings after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. FloorScore Compliance: Resilient sheet flooring shall comply with requirements of FloorScore Standard.

2.2 RUBBER SHEET FLOOR COVERING

A. Basis-of-Design Product: Subject to compliance with requirements, provide Allstate Rubber or comparable product by one of the following:
1. Flexco
2. Johnsonite
3. PRF USA Inc.
4. R.C.A. Rubber Company (The)

B. Refer to Finish Schedule included on Drawing Sheet A10.0.0 for additional information and location.

C. Product Schedule:
RS-1

Manuf.:	Allstate Rubber
Product:	Homogeneous Sheet Rubber
Color:	234
Finish:	Smooth

D. Sheet Width: As standard with manufacturer.

E. Thickness: 2 mm.

F. Seaming Method: Heat welded.

G. Colors and Patterns: Match Architect's sample.

2.3 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement based or blended hydraulic-cement-based formulation provided or approved by manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by manufacturer to suit floor covering and substrate conditions indicated.
1. Adhesives shall have a VOC content of not more than 50 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Seamless-Installation Accessories:
1. Heat-Welding Bead: Manufacturer's solid-strand product for heat welding seams.
a. Color: Match floor covering.

D. Floor Polish: Provide protective liquid floor polish products as recommended by manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of floor coverings.

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

3.2 PREPARATION

A. Prepare substrates according to manufacturer's written instructions to ensure adhesion of floor coverings.

B. Concrete Substrates: Prepare according to ASTM F 710.
1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by manufacturer. Do not use solvents.
3. Alkalinity and Adhesion Testing: Perform tests recommended by manufacturer. Proceed with installation only after substrates pass testing.
4. Moisture Testing: Perform tests recommended by manufacturer and as follows. Proceed with installation only after substrates pass testing.
   a. Perform anhydrous calcium chloride test, ASTM F 1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. in 24 hours.
   b. Perform relative humidity test using in situ probes, ASTM F 2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.

C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound and remove bumps and ridges to produce a uniform and smooth substrate.

D. Do not install floor coverings until they are same temperature as space where they are to be installed.
1. Move floor coverings and installation materials into spaces where they will be installed at least 48 hours in advance of installation.

E. Sweep and vacuum clean substrates to be covered by floor coverings immediately before installation.

3.3 FLOOR COVERING INSTALLATION

A. Comply with manufacturer's written instructions for installing floor coverings.

B. Unroll floor coverings and allow them to stabilize before cutting and fitting.

C. Lay out floor coverings as follows:
1. Maintain uniformity of floor covering direction.
2. Minimize number of seams; place seams in inconspicuous and low-traffic areas, at least 6 inches away from parallel joints in floor covering substrates.
3. Match edges of floor coverings for color shading at seams.
4. Avoid cross seams.

D. Scribe and cut floor coverings to butt neatly and tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, and door frames.

E. Extend floor coverings into toe spaces, door reveals, closets, and similar openings.

F. Maintain reference markers, holes, or openings that are in place or marked for future cutting by repeating on floor coverings as marked on substrates. Use chalk or other nonpermanent marking device.

G. Install floor coverings on covers for telephone and electrical ducts and similar items in installation areas. Maintain overall continuity of color and pattern between pieces of floor coverings installed on covers and adjoining floor covering. Tightly adhere floor covering edges to substrates that abut covers and to cover perimeters.

H. Adhere floor coverings to substrates using a full spread of adhesive applied to substrate to produce a completed installation without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.

I. Seamless Installation:
   1. Heat-Welded Seams: Comply with ASTM F 1516. Rout joints and use welding bead to permanently fuse sections into a seamless floor covering. Prepare, weld, and finish seams to produce surfaces flush with adjoining floor covering surfaces.

3.4 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protection of floor coverings.

B. Perform the following operations immediately after completing floor covering installation:
   1. Remove adhesive and other blemishes from floor covering surfaces.
   2. Sweep and vacuum floor coverings thoroughly.
   3. Damp-mop floor coverings to remove marks and soil.

C. Protect floor coverings from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

D. Cover floor coverings until Substantial Completion.

END OF SECTION

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SECTION 09 65 19

RESILIENT TILE FLOORING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Rubber floor tile.

B. Related Sections:
   1. Section 09 65 13 "Resilient Base and Accessories" for resilient base, reducer strips, and other accessories installed with resilient floor coverings.
   2. Section 09 65 16 "Resilient Sheet Flooring" for resilient sheet floor coverings.

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:
   1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
      a. Include statement indicating cost for each product having recycled content.
   2. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
   3. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
   4. Product Data for Credit IEQ 4.3: For resilient tile flooring, documentation from an independent testing agency indicating compliance with the FloorScore Standard.

C. Shop Drawings: For each type of floor tile. Include floor tile layouts, edges, columns, doorways, enclosing partitions, built-in furniture, cabinets, and cutouts.
   1. Show details of special patterns.

D. Samples for Initial Selection: For each type of floor tile indicated.

E. Samples for Verification: Full-size units of each color and pattern of floor tile required.
   1. For heat-welding bead, manufacturer's standard-size Samples, but not less than 9 inches long, of each color required.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each type of floor tile to include in maintenance manuals.

1.6 MATERIALS MAINTENANCE SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Floor Tile: Furnish 1 box for every 50 boxes or fraction thereof, of each type, color, and pattern of floor tile installed.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs workers for this Project who are competent in techniques required by manufacturer for floor tile installation and seaming method indicated.
   1. Engage an installer who employs workers for this Project who are trained or certified by manufacturer for installation techniques required.

B. Fire-Test-Response Characteristics: As determined by testing identical products according to ASTM E 648 or NFPA 253 by a qualified testing agency.
   1. Critical Radiant Flux Classification: Class I, not less than 0.45 W/sq. cm.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store floor tile and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F or more than 90 deg F. Store floor tiles on flat surfaces.

1.9 PROJECT CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F or more than 95 deg F, in spaces to receive floor tile during the following time periods:
   1. 48 hours before installation.
   2. During installation.
   3. 48 hours after installation.

B. Until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F or more than 95 deg F.

C. Close spaces to traffic during floor tile installation.

D. Close spaces to traffic for 48 hours after floor tile installation.

E. Install floor tile after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. FloorScore Compliance: Resilient tile flooring shall comply with requirements of FloorScore Standard.

2.2 RUBBER FLOOR TILE

A. Basis-of-Design Product: Subject to compliance with requirements, provide Allstate Rubber or comparable product by one of the following:
   1. Flexco (See note on Drawing Finish Schedule for work that may designate this manufacturer as the basis of design for floor type RS-2)
   2. Johnsonite
   3. PRF USA Inc.
   4. R.C.A. Rubber Company (The)

B. Refer to Finish Schedule included on Drawing Sheet A10.0.0 for additional information and location.

C. Product Schedule: For resilient floor tile.

Basis of Design

RS-2

Manuf.:	Flexco
Product:	Spextones Rubber Tile
Color:	Arctic w/ Nickel, Titanium, Linen 029
Finish:	Hammered

RS-3

Manuf.:	Allstate Rubber
Product:	Au Natural Rubber Tile
Color:	D38 – Blanc Dakota
Finish:	Granita
Size:	13.4" X 13.4"

RS-4

Manuf.:	Allstate Rubber
Product:	Au Natural Rubber Tile
Color:	D48 - Gris Paris
Finish:	Granita
Size:	13.4" X 13.4"

RS-5

Manuf.:	Allstate Rubber
Product:	Au Natural Rubber Tile
Color:	D64 - Orange
Finish:	Granita
Size:	13.4" X 13.4"

D. Tile Standard: ASTM F 1344

E. Hardness: Not less than 85 as required by ASTM F 1344, measured using Shore, Type A durometer per ASTM D 2240.

F. Thickness: 0.125 inch.

G. Colors and Patterns: Match Architect's sample.

2.3 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement based or blended hydraulic-cement-based formulation provided or approved by manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by manufacturer to suit floor tile and substrate conditions indicated.
   1. Adhesives shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
      a. Rubber Floor Adhesives: Not more than 60 g/L.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of floor tile.

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

3.2 PREPARATION

A. Prepare substrates according to manufacturer's written instructions to ensure adhesion of resilient products.

B. Concrete Substrates: Prepare according to ASTM F 710.
   1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
   2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by manufacturer. Do not use solvents.
   3. Alkalinity and Adhesion Testing: Perform tests recommended by manufacturer. Proceed with installation only after substrates pass testing.
   4. Moisture Testing: Perform tests recommended by manufacturer and as follows. Proceed with installation only after substrates pass testing.
      a. Perform anhydrous calcium chloride test, ASTM F 1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. in 24 hours.
      b. Perform relative humidity test using in situ probes, ASTM F 2170. Proceed with installation only after substrates have a maximum 75% relative humidity level measurement.

C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound and remove bumps and ridges to produce a uniform and smooth substrate.

D. Do not install floor tiles until they are same temperature as space where they are to be installed.
   1. Move resilient products and installation materials into spaces where they will be installed at least 48 hours in advance of installation.

E. Sweep and vacuum clean substrates to be covered by resilient products immediately before installation.

3.3 FLOOR TILE INSTALLATION

A. Comply with manufacturer's written instructions for installing floor tile.

B. Lay out floor tiles from center marks established with principal walls, discounting minor offsets, so tiles at opposite edges of room are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half tile at perimeter.
   1. Lay tiles square with room axis.

C. Match floor tiles for color and pattern by selecting tiles from cartons in the same sequence as manufactured and packaged, if so numbered. Discard broken, cracked, chipped, or deformed tiles.
   1. Lay tiles in pattern of colors and sizes indicated.

D. Scribe, cut, and fit floor tiles to butt neatly and tightly to vertical surfaces and permanent fixtures including built-in furniture, cabinets, pipes, outlets, and door frames.

E. Extend floor tiles into toe spaces, door reveals, closets, and similar openings. Extend floor tiles to center of door openings.

F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on floor tiles as marked on substrates. Use chalk or other nonpermanent, nonstaining marking device.

G. Adhere floor tiles to flooring substrates using a full spread of adhesive applied to substrate to produce a completed installation without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.

3.4 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protection of floor tile.

B. Perform the following operations immediately after completing floor tile installation:
   1. Remove adhesive and other blemishes from exposed surfaces.
   2. Sweep and vacuum surfaces thoroughly.
   3. Damp-mop surfaces to remove marks and soil.

C. Protect floor tile products from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

D. Cover floor tile until Substantial Completion.

END OF SECTION

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SECTION 09 68 13

TILE CARPETING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes:
1. Modular carpet tile.
2. Entry way tile

B. Related Requirements:
1. Refer to Division 09 Section “Resilient Base and Accessories”, for resilient wall base and accessories installed with carpet tile.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
1. Review methods and procedures related to carpet tile installation including, but not limited to, the following:
a. Review delivery, storage, and handling procedures.
b. Review ambient conditions and ventilation procedures.
c. Review subfloor preparation procedures.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include manufacturer's written data on physical characteristics, durability, and fade resistance.
2. Include installation recommendations for each type of substrate.

B. LEED Submittals:
1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
a. Include statement indicating cost for each product having recycled content.
2. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
3. Product Data for Credit IEQ 4.3: For carpet systems, documentation including printed statement of VOC content.
a. For carpet tile, documentation indicating compliance with testing and product requirements of CRI's "Green Label Plus" program.
b. For installation adhesive, documentation including printed statement of VOC content.
c. Documentation from an independent testing agency indicating compliance with the FloorScore Standard.

C. Shop Drawings: Show the following:
1. Columns, doorways, enclosing walls or partitions, built-in cabinets, and locations where cutouts are required in carpet tiles.

2. Carpet tile type, color, and dye lot.
3. Type of subfloor.
4. Type of installation.
5. Pattern of installation.
6. Pattern type, location, and direction.
7. Pile direction.
8. Type, color, and location of insets and borders.
9. Type, color, and location of edge, transition, and other accessory strips.
10. Transition details to other flooring materials.

D. Samples: For each of the following products and for each color and texture required. Label each Sample with manufacturer's name, material description, color, pattern, and designation indicated on Drawings and in schedules.
1. Carpet Tile: Full-size Sample.
2. Exposed Edge, Transition, and Other Accessory Stripping: 12-inch- long Samples.

E. Product Schedule: For carpet tile. Use same designations indicated on Drawings.

F. Sustainability: Provide the Statement of the Achievement Level the carpet has attained for Bronze, 28 to 36 Silver, 37 to 51 Gold, 52 to 70 points, based on specific Sustainable Attribute Performance for all product stages according to ANSI/NSF 140.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Test Reports: For carpet tile, for tests performed by a qualified testing agency.

C. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For carpet tiles to include in maintenance manuals. Include the following:
1. Methods for maintaining carpet tile, including cleaning and stain-removal products and procedures and manufacturer's recommended maintenance schedule.
2. Precautions for cleaning materials and methods that could be detrimental to carpet tile.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Carpet Tile: Full-size units equal to 5 percent of amount installed for each type indicated, but not less than 10 sq. yd..

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is certified by the International Certified Floorcovering Installers Association at the Commercial II certification level.

B. Fire-Test-Response Ratings: Where indicated, provide carpet tile identical to those of assemblies tested for fire response according to NFPA 253 by a qualified testing agency.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Comply with CRI Carpet Installation Standard 2011, First Edition.

1.10 FIELD CONDITIONS

A. Comply with CRI Carpet Installation Standard 2011, First Edition; for temperature, humidity, and ventilation limitations.

B. Environmental Limitations: Do not deliver or install carpet tiles until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and ambient temperature and humidity conditions are maintained at occupancy levels during the remainder of the construction period.

C. Do not install carpet tiles over concrete slabs until slabs have cured and are sufficiently dry to bond with adhesive and concrete slabs have pH range recommended by carpet tile manufacturer.

D. Where demountable partitions or other items are indicated for installation on top of carpet tiles, install carpet tiles before installing these items.

1.11 WARRANTY

A. Special Warranty for Carpet Tiles: Manufacturer agrees to repair or replace components of carpet tile installation that fail in materials or workmanship within specified warranty period.
   1. Warranty does not include deterioration or failure of carpet tile due to unusual traffic, failure of substrate, vandalism, or abuse.
   2. Failures include, but are not limited to, more than 10 percent edge raveling, snags, runs, dimensional stability, excess static discharge, loss of tuft bind strength, loss of face fiber, and delamination.
   3. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CARPET TILE

A. Refer to Finish Schedule included on Drawing Sheet A10.0.0 for location and additional installation information.

B. Basis-of-Design Product: Subject to compliance with requirements, provide product manufactured in the United States by the following:

CPT-1:
Manuf.: Bentley Prince Street, Inc.
Style: Satellite City
Color: Gaslamp 801055
Size: 18" X 36" Tile

CPT-2:
Manuf.: Tandus Flooring
Style: Linu Strata 02723
Color: Mineral Bath 60630
Size: 36" X 36" Tile

CPT-3:
Manuf.: Tandus Flooring
Style: Abrasive Action 02578
Color: Charcoal 19100
Size: 36" X 36" Tile

CPT-4:
Manuf.: Tandus Flooring
Style: Linu Strata 02723
Color: Iron 60521
Size: 36" X 36" Tile

C. Emissions: Provide carpet tile that complies with testing and product requirements of CRI's "Green Label Plus" program.

2.2 INSTALLATION ACCESSORIES

A. Trowelable Leveling and Patching Compounds: Latex-modified, hydraulic-cement-based formulation provided or recommended by carpet tile manufacturer.

B. Adhesives: Water-resistant, mildew-resistant, nonstaining, pressure-sensitive type to suit products and subfloor conditions indicated, that complies with flammability requirements for installed carpet tile and is recommended by carpet tile manufacturer for releasable installation.
1. Adhesives shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Metal Edge/Transition Strips: Extruded aluminum with mill finish of profile and width shown, of height required to protect exposed edge of carpet, and of maximum lengths to minimize running joints.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for maximum moisture content, alkalinity range, installation tolerances, and other conditions affecting carpet tile performance. Examine carpet tile for type, color, pattern, and potential defects.

B. Concrete Subfloors: Verify that concrete slabs comply with ASTM F 710 and the following:
1. Slab substrates are dry and free of curing compounds, sealers, hardeners, and other materials that may interfere with adhesive bond. Determine adhesion and dryness characteristics by performing bond and moisture tests recommended by carpet tile manufacturer.
2. Subfloor finishes comply with requirements specified in Section 03 30 00 "Cast-in-Place Concrete" for slabs receiving carpet tile.
3. Subfloors are free of cracks, ridges, depressions, scale, and foreign deposits.

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

3.2 PREPARATION

A. General: Comply with CRI Carpet Installation Standard 2011, First Edition, Section 7, "Site Conditions; All Installations," and with carpet tile manufacturer's written installation instructions for preparing substrates indicated to receive carpet tile installation.

B. Use trowelable leveling and patching compounds, according to manufacturer's written instructions, to fill cracks, holes, depressions, and protrusions in substrates. Fill or level cracks, holes and depressions 1/8 inch wide or wider and protrusions more than 1/32 inch unless more stringent requirements are required by manufacturer's written instructions.

C. Remove coatings, including curing compounds, and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, without using solvents. Use mechanical methods recommended in writing by carpet tile manufacturer.

D. Broom and vacuum clean substrates to be covered immediately before installing carpet tile.

3.3 INSTALLATION

A. General: Comply with CRI Carpet Installation Standard 2011, First Edition, Section 18, "Modular Carpet," and with carpet tile manufacturer's written installation instructions.

B. Installation Method: As recommended in writing by carpet tile manufacturer .

C. Maintain dye lot integrity. Do not mix dye lots in same area.

D. Cut and fit carpet tile to butt tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds, and nosings. Bind or seal cut edges as recommended by carpet tile manufacturer.

E. Extend carpet tile into toe spaces, door reveals, closets, open-bottomed obstructions, removable flanges, alcoves, and similar openings.

F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on finish flooring as marked on subfloor. Use nonpermanent, nonstaining marking device.

G. Install pattern parallel to walls and borders.

3.4 CLEANING AND PROTECTION

A. Perform the following operations immediately after installing carpet tile:
   1. Remove excess adhesive, seam sealer, and other surface blemishes using cleaner recommended by carpet tile manufacturer.
   2. Remove yarns that protrude from carpet tile surface.
   3. Vacuum carpet tile using commercial machine with face-beater element.

B. Protect installed carpet tile to comply with CRI Carpet Installation Standard 2011, First Edition, Section 20, "Protecting Indoor Installations."

C. Protect carpet tile against damage from construction operations and placement of equipment and fixtures during the remainder of construction period. Use protection methods indicated or recommended in writing by carpet tile manufacturer.

END OF SECTION

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SECTION 09 72 00

WALL COVERINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Vinyl wall covering
2. Tack panel wall covering.

B. Related Sections:
1. Division 09 Section "Interior Painting" for priming wall surfaces.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include data on physical characteristics, durability, fade resistance, and flame-resistance characteristics.

B. LEED Submittals:
1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
   a. Include statement indicating cost for each product having recycled content.
2. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
3. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
4. Product Data for Credit EQ 4.2: For paints and coatings, including printed statement of VOC content and chemical components.

C. Shop Drawings: Show location and extent of each wall-covering type. Indicate seams and termination points.

D. Samples for Initial Selection: For each type of wall covering indicated.

E. Samples for Verification: Full width by 36-inch long section of wall covering.
1. Sample from same print run or dye lot to be used for the Work, with specified paint applied. Mark top and face of fabric.

F. Product Schedule: For wall coverings. Use same designations indicated on Drawings.

G. Qualification Data: For qualified testing agency.

H. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for wall covering.

I. Maintenance Data: For wall coverings to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: As determined by testing identical wall coverings applied with identical adhesives to substrates according to test method indicated below by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Surface-Burning Characteristics: As follows, per ASTM E 84:
      a. Flame-Spread Index: 25 or less.
      b. Smoke-Developed Index: 450 or less.

B. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.
   1. Build mockups for each type of wall covering on each substrate required. Comply with requirements in ASTM F 1141.
   2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install wall coverings until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above ceilings is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   1. Wood-Veneer Wall Coverings: Condition spaces for not less than 48 hours before installation.

B. Lighting: Do not install wall covering until a permanent level of lighting is provided on the surfaces to receive wall covering.

C. Ventilation: Provide continuous ventilation during installation and for not less than the time recommended by wall-covering manufacturer for full drying or curing.

1.6 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Wall-Covering Materials: For each type, full-size units equal to 5 percent of amount installed.

PART 2 - PRODUCTS

2.1 WALL COVERINGS

A. General: Provide rolls of each type of wall covering from same print run or dye lot.

B. Refer to Finish Schedule included on Drawing Sheet A10.0.0 for additional information and location.

C. Refer to Division 01 Section “alternates” for alternates that affect the work of this section.

D. TACK WALL COVERING
   1. Wall Type; WC-1
      a. Manuf.: Maharam
      b. Product: Tek-Wall Stream 399389
      c. Color: 007 Fog
      d. Size: 54 inch wide

E. VINYL WALL COVERING
   1. Wall Type; WC-2
      a. Manuf.: Designtex
      b. Product: Digital Walls
      c. Substrate: #157 Recore Smooth
      d. Note: Custom Artwork Provided By SmithGroup

2.2 ACCESSORIES

A. Adhesive: Mildew-resistant, nonstaining adhesive, for use with specific wall covering and substrate application; as recommended in writing by wall-covering manufacturer and with a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Primer/Sealer: Mildew resistant, complying with requirements in Division 09 Section "Interior Painting" and recommended in writing by wall-covering manufacturer for intended substrate.

C. Seam Tape: As recommended in writing by wall-covering manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for levelness, wall plumbness, maximum moisture content, and other conditions affecting performance of the Work.

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

3.2 PREPARATION

A. Comply with manufacturer's written instructions for surface preparation.

B. Clean substrates of substances that could impair bond of wall covering, including dirt, oil, grease, mold, mildew, and incompatible primers.

C. Prepare substrates to achieve a smooth, dry, clean, structurally sound surface free of flaking, unsound coatings, cracks, and defects.
   1. Moisture Content: Maximum of 5 percent on new concrete, and concrete masonry units when tested with an electronic moisture meter.
   2. Metals: If not factory primed, clean and apply metal as recommended in writing by primer/sealer manufacturer and wall-covering manufacturer.
   3. Gypsum Board: Prime with primer as recommended in writing by primer/sealer manufacturer and wall-covering manufacturer.
   4. Painted Surfaces: Treat areas susceptible to pigment bleeding.

D. Check painted surfaces for pigment bleeding. Sand gloss, semigloss, and eggshell finish with fine sandpaper.

E. Remove hardware and hardware accessories, electrical plates and covers, light fixture trims, and similar items.

F. Acclimatize wall-covering materials by removing them from packaging in the installation areas not less than 24 hours before installation.

G. Install wall liner, with no gaps or overlaps, where required by wall-covering manufacturer. Form smooth wrinkle-free surface for finished installation. Do not begin wall-covering installation until wall liner has dried.

3.3 INSTALLATION

A. General: Comply with wall-covering manufacturers' written installation instructions applicable to products and applications indicated except where more stringent requirements apply.

B. Cut wall-covering strips in roll number sequence. Change roll numbers at partition breaks and corners.

C. Install strips in same order as cut from roll.

D. Install reversing every other strip.

E. Install wall covering with no gaps or overlaps, no lifted or curling edges, and no visible shrinkage.

F. Match pattern 72 inches (1830 mm) above the finish floor.

G. Install seams vertical and plumb at least 6 inches (150 mm) from outside corners and 3 inches (75 mm) from inside corners unless a change of pattern or color exists at corner. No horizontal seams are permitted.

H. Fully bond wall covering to substrate. Remove air bubbles, wrinkles, blisters, and other defects.

I. Trim edges and seams for color uniformity, pattern match, and tight closure. Butt seams without any overlay or spacing between strips.

3.4 CLEANING

A. Remove excess adhesive at finished seams, perimeter edges, and adjacent surfaces.

B. Use cleaning methods recommended in writing by wall-covering manufacturer.

C. Replace strips that cannot be cleaned.

D. Reinstall hardware and hardware accessories, electrical plates and covers, light fixture trims, and similar items.

END OF SECTION

SECTION 09 91 13

EXTERIOR PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes surface preparation and the application of paint systems on exterior substrates. the following exterior substrates:
   1. Concrete.
   2. Steel.
   3. Galvanized metal.
   4. Exterior gypsum board.

B. Related Requirements:
   1. Section 05 12 00 "Structural Steel Framing" for shop priming of metal substrates with primers specified in this Section.
   2. Section 09 96 00 "High-Performance Coatings" for special-use coatings.
   3. Section 09 91 23 "Interior Painting" for surface preparation and the application of paint systems on interior substrates.

1.3 DEFINITIONS

A. Gloss Level 1: Not more than 5 units at 60 degrees and 10 units at 85 degrees, according to ASTM D 523.

B. Gloss Level 3: 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523.

C. Gloss Level 4: 20 to 35 units at 60 degrees and not less than 35 units at 85 degrees, according to ASTM D 523.

D. Gloss Level 5: 35 to 70 units at 60 degrees, according to ASTM D 523.

E. Gloss Level 6: 70 to 85 units at 60 degrees, according to ASTM D 523.

F. Gloss Level 7: More than 85 units at 60 degrees, according to ASTM D 523.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include preparation requirements and application instructions.

B. LEED Submittals:
   1. Product Data for Credit IEQ 4.2: For Paints and Coatings, documentation including printed statement of VOC content.

C. Samples for Initial Selection: For each type of topcoat product.

D. Samples for Verification: For each type of paint system and each color and gloss of topcoat.
   1. Submit Samples on rigid backing, 8 inches square.
   2. Step coats on Samples to show each coat required for system.
   3. Label each coat of each Sample.
   4. Label each Sample for location and application area.

E. Product List: For each product indicated, include the following:
   1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
   2. Printout of current "MPI Approved Products List" for each product category specified, with the proposed product highlighted.
   3. VOC content.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Paint: 5 percent, but not less than 1 gal. of each material and color applied.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.
   1. Maintain containers in clean condition, free of foreign materials and residue.
   2. Remove rags and waste from storage areas daily.

1.7 FIELD CONDITIONS

A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F.

B. Do not apply paints in snow, rain, fog, or mist; when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 PAINT, GENERAL

A. MPI Standards: Provide products that comply with MPI standards indicated and that are listed in its "MPI Approved Products List."

B. Material Compatibility:
   1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
   2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.

C. VOC Content: Provide materials that comply with VOC limits of authorities having jurisdiction.

D. Colors: Match Architect's samples.
   1. 10 percent of surface area will be painted with deep tones.

2.2 BLOCK FILLERS

A. Block Filler, Latex, Interior/Exterior: MPI #4.

2.3 PRIMERS/SEALERS

A. Primer, Alkali Resistant, Water Based: MPI #3.

B. Primer, Bonding, Water Based: MPI #17.

C. Primer, Bonding, Solvent Based: MPI #69.

2.4 METAL PRIMERS

A. Primer, Alkyd, Anti-Corrosive for Metal: MPI #79.

B. Primer, Alkyd, Quick Dry, for Metal: MPI #76.

C. Primer, Galvanized, Water Based: MPI #134.

D. Primer, Quick Dry, for Aluminum: MPI #95.

2.5 WATER-BASED PAINTS

A. Latex, Exterior Flat (Gloss Level 1): MPI #10.

B. Latex, Exterior Semi-Gloss (Gloss Level 5): MPI #11.

C. Latex, Exterior, Gloss (Gloss Level 6: MPI #119.

D. Light Industrial Coating, Exterior, Water Based (Gloss Level 3): MPI #161.

E. Light Industrial Coating, Exterior, Water Based, Semi-Gloss (Gloss Level 5): MPI #163.

F. Light Industrial Coating, Exterior, Water Based, Gloss (Gloss Level 6): MPI #164.

2.6 SOLVENT-BASED PAINTS

A. Alkyd, Exterior Flat (Gloss Level 1): MPI #8.

B. Alkyd, Exterior, Semi-Gloss (Gloss Level 5): MPI #94.

C. Alkyd, Exterior Gloss (Gloss Level 6): MPI #9.

D. Alkyd, Quick Dry, Semi-Gloss (Gloss Level 5): MPI #81.

E. Alkyd, Quick Dry, Gloss (Gloss Level 7): MPI #96.

2.7 ALUMINUM PAINT

A. Aluminum Paint: MPI #1.

2.8 SOURCE QUALITY CONTROL

A. Testing of Paint Materials: Owner reserves the right to invoke the following procedure:
   1. Owner will engage the services of a qualified testing agency to sample paint materials. Contractor will be notified in advance and may be present when samples are taken. If paint materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
   2. Testing agency will perform tests for compliance with product requirements.
   3. Owner may direct Contractor to stop applying paints if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying paint materials from Project site, pay for testing, and repaint surfaces painted with rejected materials. Contractor will be required to remove rejected materials from previously painted surfaces if, on repainting with complying materials, the two paints are incompatible.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
   1. Concrete: 12 percent.
   2. Gypsum Board: 12 percent.

C. Exterior Gypsum Board Substrates: Verify that finishing compound is sanded smooth.

D. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.

E. Proceed with coating application only after unsatisfactory conditions have been corrected.
   1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations in "MPI Manual" applicable to substrates and paint systems indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
   1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection.

C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
   1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.

D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.

E. Steel Substrates: Remove rust, loose mill scale, and shop primer if any. Clean using methods recommended in writing by paint manufacturer but not less than the following:
   1. SSPC-SP 2, "Hand Tool Cleaning."
   2. SSPC-SP 3, "Power Tool Cleaning."
   3. SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
   4. SSPC-SP 11, "Power Tool Cleaning to Bare Metal."

F. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.

G. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.

3.3 APPLICATION

A. Apply paints according to manufacturer's written instructions and recommendations in "MPI Manual."
   1. Use applicators and techniques suited for paint and substrate indicated.
   2. Paint surfaces behind movable items same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed items with prime coat only.
   3. Paint both sides and edges of exterior doors and entire exposed surface of exterior door frames.
   4. Paint entire exposed surface of window frames and sashes.
   5. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
   6. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.

B. Tint undercoats same color as topcoat, but tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Provide sufficient difference in shade of undercoats to distinguish each separate coat.

C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.

D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

E. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:
   1. Paint the following work where exposed to view:
      a. Equipment, including panelboards and switch gear.
      b. Uninsulated metal piping.
      c. Uninsulated plastic piping.
      d. Pipe hangers and supports.
      e. Metal conduit.
      f. Plastic conduit.
      g. Tanks that do not have factory-applied final finishes.
      h. Insert mechanical items to be painted.

3.4 FIELD QUALITY CONTROL

A. Dry Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry film thickness.
   1. Contractor shall touch up and restore painted surfaces damaged by testing.

2. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.6 EXTERIOR PAINTING SCHEDULE

A. Concrete Substrates, Nontraffic Surfaces:
1. Latex System:
   a. Prime Coat: Primer, alkali resistant, water based, MPI #3.
   b. Intermediate Coat: Latex, exterior, matching topcoat.
   c. Topcoat: Latex, exterior flat (Gloss Level 1), MPI #10.
   d. Topcoat: Latex, exterior, low sheen (Gloss Level 3-4), MPI #15.
   e. Topcoat: Latex, exterior semi-gloss (Gloss Level 5), MPI #11.
   f. Topcoat: Latex, exterior gloss (Gloss Level 6), MPI #119.

B. Concrete Substrates, Traffic Surfaces:
1. Latex Floor Paint System:
   a. Prime Coat: Floor paint, latex, low gloss (maximum Gloss Level 3), MPI #60.
   b. Intermediate Coat: Floor paint, latex, low gloss (maximum Gloss Level 3), MPI #60.
   c. Topcoat: Floor paint, latex, low gloss (maximum Gloss Level 3), MPI #60.
   d. Minimum System DFT: 3.5 mils .
2. Water-Based Clear Sealer System:
   a. Prime Coat: Sealer, water based, for concrete floors, MPI #99.
   b. Intermediate Coat: Sealer, water based, for concrete floors, MPI #99.
   c. Topcoat: Sealer, water based, for concrete floors, MPI #99.
3. Solvent-Based Clear Sealer System:
   a. Prime Coat: Sealer, solvent based, for concrete floors, MPI #104.
   b. Intermediate Coat: Sealer, solvent based, for concrete floors, MPI #104.
   c. Topcoat: Sealer, solvent based, for concrete floors, MPI #104.

C. CMU Substrates:
1. Latex System:
   a. Prime Coat: Block filler, latex, interior/exterior, MPI #4.
   b. Topcoat: Latex, exterior flat (Gloss Level 1), MPI #10.
   c. Topcoat: Latex, exterior, low sheen (Gloss Level 3-4), MPI #15.
   d. Topcoat: Latex, exterior semi-gloss (Gloss Level 5), MPI #11.
   e. Topcoat: Latex, exterior gloss (Gloss Level 6), MPI #119.
2. Latex over Alkali-Resistant Primer System:
   a. Prime Coat: Primer, alkali resistant, water based, MPI #3.
   b. Topcoat: Latex, exterior flat (Gloss Level 1), MPI #10.

c. Topcoat: Latex, exterior, low sheen (Gloss Level 3-4), MPI #15.
d. Topcoat: Latex, exterior semi-gloss (Gloss Level 5), MPI #11.
e. Topcoat: Latex, exterior gloss (Gloss Level 6), MPI #119.

D. Steel Substrates:
1. Water-Based Light Industrial Coating System:
a. Prime Coat: Primer, alkyd, anti-corrosive for metal, MPI #79.
b. Topcoat: Light industrial coating, exterior, water based (Gloss Level 3), MPI #161.
c. Topcoat: Light industrial coating, exterior, water based, semi-gloss (Gloss Level 5), MPI #163.
d. Topcoat: Light industrial coating, exterior, water based, gloss (Gloss Level 6), MPI #164.
2. Alkyd System:
a. Prime Coat: Primer, alkyd, anticorrosive for metal, MPI #79.
b. Prime Coat: Shop primer specified in Section 051200 "Structural Steel Framing" where substrate is specified.
c. Intermediate Coat: Exterior alkyd enamel matching topcoat.
d. Topcoat: Alkyd, exterior, flat (Gloss Level 1), MPI #8.
e. Topcoat: Alkyd, exterior, semi-gloss (Gloss Level 5), MPI #94.
f. Topcoat: Alkyd, exterior, gloss (Gloss Level 6), MPI #9.
3. Quick-Drying Enamel System:
a. Prime Coat: Primer, alkyd, quick dry, for metal, MPI #76.
b. Intermediate Coat: Alkyd, quick dry, matching topcoat.
c. Topcoat: Alkyd, quick dry, semi-gloss (Gloss Level 5), MPI #81.
d. Topcoat: Alkyd, quick dry, gloss (Gloss Level 7), MPI #96.
4. Aluminum Paint System:
a. Prime Coat: Primer, alkyd, anti-corrosive for metal, MPI #79.
b. Intermediate Coat: Aluminum paint, MPI #1.
c. Topcoat: Aluminum paint, MPI #1.

E. Galvanized-Metal Substrates:
1. Latex System:
a. Prime Coat: Primer, galvanized, water based, MPI #134.
b. Topcoat: Latex, exterior flat (Gloss Level 1), MPI #10.
c. Topcoat: Latex, exterior, low sheen (Gloss Level 3-4), MPI #15.
d. Topcoat: Latex, exterior semi-gloss (Gloss Level 5), MPI #11.
e. Topcoat: Latex, exterior gloss (Gloss Level 6), MPI #119.
2. Water-Based Light Industrial Coating System:
a. Prime Coat: Primer, galvanized, water based, MPI #134.
b. Topcoat: Light industrial coating, exterior, water based (Gloss Level 3), MPI #161.
c. Topcoat: Light industrial coating, exterior, water based, semi-gloss (Gloss Level 5), MPI #163.
d. Topcoat: Light industrial coating, exterior, water based, gloss (Gloss Level 6), MPI #164.
3. Alkyd System:
a. Topcoat: Alkyd, exterior, flat (Gloss Level 5), MPI #8.
b. Topcoat: Alkyd, exterior, semi-gloss (Gloss Level 5), MPI #94.
c. Topcoat: Alkyd, exterior, gloss (Gloss Level 5), MPI #9.

F. Aluminum Substrates:
1. Latex System:
a. Prime Coat: Primer, quick dry, for aluminum, MPI #95.
b. Topcoat: Latex, exterior flat (Gloss Level 1), MPI #10.
c. Topcoat: Latex, exterior, low sheen (Gloss Level 3-4), MPI #15.
d. Topcoat: Latex, exterior semi-gloss (Gloss Level 5), MPI #11.
e. Topcoat: Latex, exterior gloss (Gloss Level 6), MPI #119.

2. Water-Based Light Industrial Coating System:
   a. Prime Coat: Primer, quick dry, for aluminum, MPI #95.
   b. Topcoat: Light industrial coating, exterior, water based (Gloss Level 3), MPI #161.
   c. Topcoat: Light industrial coating, exterior, water based, semi-gloss (Gloss Level 5), MPI #163.
   d. Topcoat: Light industrial coating, exterior, water based, gloss (Gloss Level 6), MPI #164.
3. Alkyd System:
   a. Prime Coat: Primer, quick dry, for aluminum, MPI #95.
   b. Topcoat: Alkyd, exterior, flat (Gloss Level 5), MPI #8.
   c. Topcoat: Alkyd, exterior, semi-gloss (Gloss Level 5), MPI #94.
   d. Topcoat: Alkyd, exterior, gloss (Gloss Level 5), MPI #9.

G. Portland Cement Plaster Substrates:
1. Latex System:
   a. Topcoat: Latex, exterior flat (Gloss Level 1), MPI #10.
   b. Topcoat: Latex, exterior, low sheen (Gloss Level 3-4), MPI #15.
   c. Topcoat: Latex, exterior semi-gloss (Gloss Level 5), MPI #11.
   d. Topcoat: Latex, exterior gloss (Gloss Level 6), MPI #119.
2. Latex over Alkali-Resistant Primer System:
   a. Prime Coat: Primer, alkali resistant, water based, MPI #3.
   b. Topcoat: Latex, exterior flat (Gloss Level 1), MPI #10.
   c. Topcoat: Latex, exterior, low sheen (Gloss Level 3-4), MPI #15.
   d. Topcoat: Latex, exterior semi-gloss (Gloss Level 5), MPI #11.
   e. Topcoat: Latex, exterior gloss (Gloss Level 6), MPI #119.

H. Exterior Gypsum Board Substrates:
1. Latex System:
   a. Prime Coat: Latex, exterior, matching topcoat.
   b. Intermediate Coat: Latex, exterior, matching topcoat.
   c. Topcoat: Latex, exterior flat (Gloss Level 1), MPI #10.
   d. Topcoat: Latex, exterior, low sheen (Gloss Level 3-4), MPI #15.
   e. Topcoat: Latex, exterior semi-gloss (Gloss Level 5), MPI #11.
   f. Topcoat: Latex, exterior gloss (Gloss Level 6), MPI #119.

END OF SECTION

SECTION 09 91 23

INTERIOR PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes surface preparation and the application of paint systems on the following interior substrates:
   1. Concrete.
   2. Concrete masonry units (CMU).
   3. Steel.
   4. Galvanized metal.
   5. Aluminum (not anodized or otherwise coated).
   6. Gypsum board.

B. Related Requirements:
   1. Section 09 91 13 "Exterior Painting" for surface preparation and the application of paint systems on exterior substrates.
   2. Section 09 96 00 "High-Performance Coatings" for high-performance and special-use coatings.

1.3 DEFINITIONS

A. Gloss Level 1: Not more than 5 units at 60 degrees and 10 units at 85 degrees, according to ASTM D 523.

B. Gloss Level 2: Not more than 10 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523.

C. Gloss Level 3: 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523.

D. Gloss Level 4: 20 to 35 units at 60 degrees and not less than 35 units at 85 degrees, according to ASTM D 523.

E. Gloss Level 5: 35 to 70 units at 60 degrees, according to ASTM D 523.

F. Gloss Level 6: 70 to 85 units at 60 degrees, according to ASTM D 523.

G. Gloss Level 7: More than 85 units at 60 degrees, according to ASTM D 523.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include preparation requirements and application instructions.

B. LEED Submittals:
1. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
2. Product Data for Credit IEQ 4.2: For paints and coatings, including printed statement of VOC content.

C. Samples for Initial Selection: For each type of topcoat product.

D. Samples for Verification: For each type of paint system and in each color and gloss of topcoat.
1. Submit Samples on rigid backing, 8 inches square.
2. Step coats on Samples to show each coat required for system.
3. Label each coat of each Sample.
4. Label each Sample for location and application area.

E. Product List: For each product indicated, include the following:
1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
2. Printout of current "MPI Approved Products List" for each product category specified in Part 2, with the proposed product highlighted.
3. VOC content.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Paint: 5 percent, but not less than 1 gal. of each material and color applied.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.
1. Maintain containers in clean condition, free of foreign materials and residue.
2. Remove rags and waste from storage areas daily.

1.7 FIELD CONDITIONS

A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F.

B. Do not apply paints when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Benjamin Moore & Co.
2. Duron, Inc.
3. ICI Paints.
4. M.A.B. Paints.

5. PPG Architectural Finishes, Inc.
6. Pratt & Lambert.
7. Sherwin-Williams Company (The).

B. Refer to Finish Schedule for Paint Types P-1 through P-3 and P-6 through P-10 on the Drawings for Interior Paint selection.
1. Refer to Section 09 “High Performance Coatings” and Finish Schedule for Paint Types P-4 and P-5.

2.2 PAINT, GENERAL

A. MPI Standards: Provide products that comply with MPI standards indicated and that are listed in its "MPI Approved Products List."

B. Material Compatibility:
1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.

C. VOC Content: Products shall comply with VOC limits of authorities having jurisdiction and, for interior paints and coatings applied at Project site, the following VOC limits, exclusive of colorants added to a tint base, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
1. Flat Paints and Coatings: 50 g/L.
2. Nonflat Paints and Coatings: 150 g/L.
3. Dry-Fog Coatings: 400 g/L.
4. Primers, Sealers, and Undercoaters: 200 g/L.
5. Anticorrosive and Antirust Paints Applied to Ferrous Metals: 250 g/L.
6. Zinc-Rich Industrial Maintenance Primers: 340 g/L.
7. Pretreatment Wash Primers: 420 g/L.
8. Floor Coatings: 100 g/L.
9. Shellacs, Clear: 730 g/L.
10. Shellacs, Pigmented: 550 g/L.

D. Colors: Match Architect's samples.
1. 20 percent of surface area will be painted with deep tones.

2.3 BLOCK FILLERS

A. Block Filler, Latex, Interior/Exterior: MPI #4.

2.4 PRIMERS/SEALERS

A. Primer Sealer, Latex, Interior: MPI #50.

B. Primer Sealer, Interior, Institutional Low Odor/VOC: MPI #149.

C. Primer Sealer, Alkyd, Interior: MPI #45.

D. Primer, Bonding, Water Based: MPI #17.

2.5 METAL PRIMERS

A. Primer, Rust-Inhibitive, Water Based: MPI #107.

B. Primer, Alkyd, Anti-Corrosive, for Metal: MPI #79.

C. Primer, Alkyd, Quick Dry, for Metal: MPI #76.

D. Primer, Galvanized, Water Based: MPI #134.

2.6 WATER-BASED PAINTS

A. Latex, Interior, Institutional Low Odor/VOC, Flat (Gloss Level 1): MPI #143.

B. Latex, Interior, Institutional Low Odor/VOC, (Gloss Level 2): MPI #144.

C. Latex, Interior, Institutional Low Odor/VOC, (Gloss Level 3): MPI #145.

D. Latex, Interior, Institutional Low Odor/VOC, Semi-Gloss (Gloss Level 5): MPI #147.

E. Latex, Interior, High Performance Architectural, (Gloss Level 2): MPI #138.

F. Latex, Interior, High Performance Architectural, (Gloss Level 3): MPI #139.

G. Latex, Interior, High Performance Architectural, (Gloss Level 4): MPI #140.

H. Latex, Interior, High Performance Architectural, Semi-Gloss (Gloss Level 5): MPI #141.

2.7 DRY FOG/FALL COATINGS

A. Dry Fall, Latex, Flat: MPI #118.

B. Dry Fall, Water Based, for Galvanized Steel, Flat (Gloss Level 1): MPI #133.

C. Dry Fall, Alkyd, Flat: MPI #55.

2.8 ALUMINUM PAINT

A. Aluminum Paint: MPI #1.

2.9 FLOOR COATINGS

A. Sealer, Water Based, for Concrete Floors: MPI #99.

B. Floor Enamel, Alkyd, Gloss (Gloss Level 6): MPI #27.

2.10 SOURCE QUALITY CONTROL

A. Testing of Paint Materials: Owner reserves the right to invoke the following procedure:
   1. Owner will engage the services of a qualified testing agency to sample paint materials. Contractor will be notified in advance and may be present when samples are taken. If paint materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
   2. Testing agency will perform tests for compliance with product requirements.

3. Owner may direct Contractor to stop applying coatings if test results show materials being used do not comply with product requirements. Contractor shall remove non-complying paint materials from Project site, pay for testing, and repaint surfaces painted with rejected materials. Contractor will be required to remove rejected materials from previously painted surfaces if, on repainting with complying materials, the two paints are incompatible.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
1. Concrete: 12 percent.
2. Masonry (Clay and CMU): 12 percent.
3. Gypsum Board: 12 percent.

C. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.

D. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.

E. Proceed with coating application only after unsatisfactory conditions have been corrected.
1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations in "MPI Manual" applicable to substrates indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.

C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.

D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.

E. Masonry Substrates: Remove efflorescence and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces or mortar joints exceed that permitted in manufacturer's written instructions.

F. Steel Substrates: Remove rust, loose mill scale, and shop primer, if any. Clean using methods recommended in writing by paint manufacturer but not less than the following:
1. SSPC-SP 2, "Hand Tool Cleaning."
2. SSPC-SP 3, "Power Tool Cleaning."

3. SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
4. SSPC-SP 11, "Power Tool Cleaning to Bare Metal."

G. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.

H. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal fabricated from coil stock by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.

I. Aluminum Substrates: Remove loose surface oxidation.

3.3 APPLICATION

A. Apply paints according to manufacturer's written instructions and to recommendations in "MPI Manual."
1. Use applicators and techniques suited for paint and substrate indicated.
2. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
3. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
5. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.

B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Tint undercoats to match color of topcoat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.

C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.

D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

E. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:
1. Paint the following work where exposed in equipment rooms:
   a. Equipment, including panelboards and switch gear.
   b. Uninsulated metal piping.
   c. Uninsulated plastic piping.
   d. Pipe hangers and supports.
   e. Metal conduit.
   f. Plastic conduit.
   g. Tanks that do not have factory-applied final finishes.
   h. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
2. Paint the following work where exposed in occupied spaces:
   a. Equipment, including panelboards.
   b. Uninsulated metal piping.
   c. Uninsulated plastic piping.
   d. Pipe hangers and supports.

e. Metal conduit.
f. Plastic conduit.
g. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
h. Other items as directed by Architect.

3. Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that are visible from occupied spaces.

3.4 FIELD QUALITY CONTROL

A. Dry Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry film thickness.
1. Contractor shall touch up and restore painted surfaces damaged by testing.
2. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.6 INTERIOR PAINTING SCHEDULE

A. Concrete Substrates, Nontraffic Surfaces:
1. Latex System:
a. Prime Coat: Primer sealer, latex, interior, MPI #50.
b. Topcoat: Latex, interior, flat, (Gloss Level 1), MPI #53.
c. Topcoat: Latex, interior, (Gloss Level 2), MPI #44.
d. Topcoat: Latex, interior, (Gloss Level 3), MPI #52.
e. Topcoat: Latex, interior, (Gloss Level 4), MPI #43.
f. Topcoat: Latex, interior, semi-gloss, (Gloss Level 5), MPI #54.
g. Topcoat: Latex, interior, gloss, (Gloss Level 6, except minimum gloss of 65 units at 60 degrees), MPI #114.
2. Institutional Low-Odor/VOC Latex System:
a. Prime Coat: Primer sealer, interior, institutional low odor/VOC, MPI #149.
b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.
c. Topcoat: Latex, interior, institutional low odor/VOC, flat (Gloss Level 1), MPI #143.
d. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 2), MPI #144.
e. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 3), MPI #145.
f. Topcoat: Latex, interior, institutional low odor/VOC, semi-gloss (Gloss Level 5), MPI #147.

3. High-Performance Architectural Latex System:
   a. Prime Coat: Primer, alkali resistant, water based, MPI #3.
   b. Topcoat: Latex, interior, high performance architectural, (Gloss Level 2), MPI #138.
   c. Topcoat: Latex, interior, high performance architectural, (Gloss Level 3), MPI #139.
   d. Topcoat: Latex, interior, high performance architectural, (Gloss Level 4), MPI #140.
   e. Topcoat: Latex, interior, high performance architectural, semi-gloss (Gloss Level 5), MPI #141.

B. Concrete Substrates, Traffic Surfaces:
1. Latex Floor Enamel System:
   a. Prime Coat: Floor paint, latex, low gloss (maximum Gloss Level 3), MPI #60.
   b. Intermediate Coat: Floor paint, latex, low gloss (maximum Gloss Level 3), MPI #60.
   c. Topcoat: Floor paint, latex, low gloss (maximum Gloss Level 3), MPI #60.
2. Concrete Stain System:
   a. First Coat: Stain, interior, for concrete floors, MPI #58.
   b. Topcoat: Stain, interior, for concrete floors, MPI #58.
3. Water-Based Clear Sealer System:
   a. First Coat: Sealer, water based, for concrete floors, MPI #99.
   b. Topcoat: Sealer, water based, for concrete floors, MPI #99.

C. CMU Substrates:
1. Institutional Low-Odor/VOC Latex System:
   a. Block Filler: Block filler, latex, interior/exterior, MPI #4.
   b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.
   c. Topcoat: Latex, interior, institutional low odor/VOC, flat (Gloss Level 1), MPI #143.
   d. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 2), MPI #144.
   e. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 3), MPI #145.
   f. Topcoat: Latex, interior, institutional low odor/VOC, semi-gloss (Gloss Level 5), MPI #147.
2. Water-Based Light Industrial Coating System:
   a. Block Filler: Block filler, latex, interior/exterior, MPI #4.
   b. Topcoat: Light industrial coating, interior, water based (Gloss Level 3), MPI #151.
   c. Topcoat: Light industrial coating, interior, water based, semi-gloss (Gloss Level 5), MPI #153.
   d. Topcoat: Light industrial coating, interior, water based, gloss (Gloss Level 6), MPI #154.

D. Steel Substrates:
1. Latex over Alkyd Primer System:
   a. Prime Coat: Primer, alkyd, anti-corrosive, for metal, MPI #79 or primer, alkyd, quick dry, for metal, MPI #76.
   b. Topcoat: Latex, interior, flat, (Gloss Level 1), MPI #53.
   c. Topcoat: Latex, interior, (Gloss Level 2), MPI #44.
   d. Topcoat: Latex, interior, (Gloss Level 3), MPI #52.
   e. Topcoat: Latex, interior, (Gloss Level 4), MPI #43.
   f. Topcoat: Latex, interior, semi-gloss, (Gloss Level 5), MPI #54.
   g. Topcoat: Latex, interior, gloss, (Gloss Level 6, except minimum gloss of 65 units at 60 degrees), MPI #114.
2. Water-Based Dry-Fall System:
   a. Prime Coat: Primer, alkyd, anti-corrosive, for metal, MPI #79 or primer, alkyd, quick dry, for metal, MPI #76.
   b. Topcoat: Dry fall, latex, flat, MPI #118.
   c. Topcoat: Dry fall, water based, for galvanized steel, flat (Gloss Level 1), MPI #133.

3. Institutional Low-Odor/VOC Latex System:
   a. Prime Coat: Primer, rust-inhibitive, water based MPI #107.
   b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.
   c. Topcoat: Latex, interior, institutional low odor/VOC, flat (Gloss Level 1), MPI #143.
   d. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 2), MPI #144.
   e. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 3), MPI #145.
   f. Topcoat: Latex, interior, institutional low odor/VOC, semi-gloss (Gloss Level 5), MPI #147.
4. High-Performance Architectural Latex System:
   a. Prime Coat: Primer, alkyd, anti-corrosive, for metal, MPI #79.
   b. Prime Coat: Primer, alkyd, quick dry, for metal, MPI #76.
   c. Prime Coat: Primer, alkyd, anti-corrosive, for metal, MPI #79 or primer, alkyd, quick dry, for metal.
   d. Topcoat: Latex, interior, high performance architectural, (Gloss Level 2), MPI #138.
   e. Topcoat: Latex, interior, high performance architectural, (Gloss Level 3), MPI #139.
   f. Topcoat: Latex, interior, high performance architectural, (Gloss Level 4), MPI #140.
   g. Topcoat: Latex, interior, high performance architectural, semi-gloss (Gloss Level 5), MPI #141.
5. Water-Based Light Industrial Coating System:
   a. Prime Coat: Primer, rust-inhibitive, water based MPI #107.
   b. Topcoat: Light industrial coating, interior, water based (Gloss Level 3), MPI #151.
   c. Topcoat: Light industrial coating, interior, water based, semi-gloss (Gloss Level 5), MPI #153.
   d. Topcoat: Light industrial coating, interior, water based, gloss (Gloss Level 6), MPI #154.
6. Quick-Drying Enamel System:
   a. Prime Coat: Primer, alkyd, quick dry, for metal, MPI #76.
   b. Topcoat: Alkyd, quick dry, semi-gloss (Gloss Level 5), MPI #81.
   c. Topcoat: Alkyd, quick dry, gloss (Gloss Level 7), MPI #96.
7. Aluminum Paint System:
   a. Prime Coat: Primer, alkyd, anti-corrosive, for metal, MPI #79 or primer, alkyd, quick dry, for metal.
   b. Intermediate Coat: Aluminum paint, MPI #1.
   c. Topcoat: Aluminum paint, MPI #1.

E. Galvanized-Metal Substrates:
1. Latex over Waterborne Primer System:
   a. Prime Coat: Primer, galvanized, water based, MPI #134.
   b. Topcoat: Latex, interior, flat, (Gloss Level 1), MPI #53.
   c. Topcoat: Latex, interior, (Gloss Level 2), MPI #44.
   d. Topcoat: Latex, interior, (Gloss Level 3), MPI #52.
   e. Topcoat: Latex, interior, (Gloss Level 4), MPI #43.
   f. Topcoat: Latex, interior, semi-gloss, (Gloss Level 5), MPI #54.
   g. Topcoat: Latex, interior, gloss, (Gloss Level 6, except minimum gloss of 65 units at 60 degrees), MPI #114.
2. Water-Based Dry-Fall System:
   a. Prime Coat: Dry fall, water based, for galvanized steel, flat (Gloss Level 1), MPI #133.
   b. Topcoat: Dry fall, water based, for galvanized steel, flat (Gloss Level 1), MPI #133.
3. Institutional Low-Odor/VOC Latex System:
   a. Prime Coat: Primer, galvanized, water based, MPI #134.
   b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.
   c. Topcoat: Latex, interior, institutional low odor/VOC, flat (Gloss Level 1), MPI #143.
   d. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 2), MPI #144.
   e. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 3), MPI #145.
   f. Topcoat: Latex, interior, institutional low odor/VOC, semi-gloss (Gloss Level 5), MPI #147.

4. Water-Based Light Industrial Coating Over Waterborne Primer System:
   a. Prime Coat: Primer, galvanized, water based, MPI #134.
   b. Topcoat: Light industrial coating, interior, water based (Gloss Level 3), MPI #151.
   c. Topcoat: Light industrial coating, interior, water based, semi-gloss (Gloss Level 5), MPI #153.
   d. Topcoat: Light industrial coating, interior, water based, gloss (Gloss Level 6), MPI #154.
5. Aluminum Paint System:
   a. Intermediate Coat: Aluminum paint, MPI #1.
   b. Topcoat: Aluminum paint, MPI #1.

F. Aluminum (Not Anodized or Otherwise Coated) Substrates:
1. Institutional Low-Odor/VOC Latex System:
   a. Prime Coat: Primer, quick dry, for aluminum, MPI #95.
   b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.
   c. Topcoat: Latex, interior, institutional low odor/VOC, flat (Gloss Level 1), MPI #143.
   d. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 2), MPI #144.
   e. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 3), MPI #145.
   f. Topcoat: Latex, interior, institutional low odor/VOC, semi-gloss (Gloss Level 5), MPI #147.
2. High-Performance Architectural Latex System:
   a. Prime Coat: Primer, quick dry, for aluminum, MPI #95.
   b. Topcoat: Latex, interior, high performance architectural, (Gloss Level 2), MPI #138.
   c. Topcoat: Latex, interior, high performance architectural, (Gloss Level 3), MPI #139.
   d. Topcoat: Latex, interior, high performance architectural, (Gloss Level 4), MPI #140.
   e. Topcoat: Latex, interior, high performance architectural, semi-gloss (Gloss Level 5), MPI #141.
3. Water-Based Light Industrial Coating System:
   a. Prime Coat: Primer, quick dry, for aluminum, MPI #95.
   b. Topcoat: Light industrial coating, interior, water based (Gloss Level 3), MPI #151.
   c. Topcoat: Light industrial coating, interior, water based, semi-gloss (Gloss Level 5), MPI #153.
   d. Topcoat: Light industrial coating, interior, water based, gloss (Gloss Level 6), MPI #154.

G. Gypsum Board Substrates:
1. Institutional Low-Odor/VOC Latex System:
   a. Prime Coat: Primer sealer, interior, institutional low odor/VOC, MPI #149.
   b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.
   c. Topcoat: Latex, interior, institutional low odor/VOC, flat (Gloss Level 1), MPI #143.
   d. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 2), MPI #144.
   e. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 3), MPI #145.
   f. Topcoat: Latex, interior, institutional low odor/VOC, semi-gloss (Gloss Level 5), MPI #147.
2. High-Performance Architectural Latex System:
   a. Prime Coat: Primer sealer, latex, interior, MPI #50.
   b. Topcoat: Latex, interior, high performance architectural, (Gloss Level 2), MPI #138.
   c. Topcoat: Latex, interior, high performance architectural, (Gloss Level 3), MPI #139.
   d. Topcoat: Latex, interior, high performance architectural, (Gloss Level 4), MPI #140.
   e. Topcoat: Latex, interior, high performance architectural, semi-gloss (Gloss Level 5), MPI #141.

END OF SECTION

SECTION 09 96 00

HIGH-PERFORMANCE COATINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes surface preparation and application of high-performance coating systems on the following substrates:
   1. Exposed Steel:

B. Related Requirements:
   1. Section 09 91 13 "Exterior Painting" for special-use coatings and general field painting.
   2. Section 09 91 23 "Interior Painting" for special-use coatings and general field painting.

1.3 DEFINITIONS

A. Gloss Level 6: 70 to 85 units at 60 degrees, according to ASTM D 523.

B. Gloss Level 7: More than 85 units at 60 degrees, according to ASTM D 523.

C. Dry Film Thickness (DFT): Measure dry film thickness of new coating system using ASTM D4138 Standard Test Method for Measurement of Dry Film Thickness of Protective Coatings Systems by Destructive Means.
   1. Perform 3 tests at random intervals

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include preparation requirements and application instructions.

B. LEED Submittals:
   1. Product Data for Credit IEQ 4.2: For interior coatings, documentation including printed statement of VOC content.

C. Samples for Initial Selection: For each type of topcoat product indicated.

D. Samples for Verification: For each type of coating system and in each color and gloss of topcoat indicated.
   1. Submit Samples on steel surface, 8 inches square.
   2. Step coats on Samples to show each coat required for system.
   3. Label each coat of each Sample.
   4. Label each Sample for location and application area.

E. Product List: For each product indicated, include the following:
   1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
   2. Printout of current "MPI Approved Products List" for each product category specified in Part 2, with the proposed product highlighted.
   3. VOC content.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Coatings: 5 percent, but not less than 1 gal. of each material and color applied.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.
   1. Maintain containers in clean condition, free of foreign materials and residue.
   2. Remove rags and waste from storage areas daily.

1.7 FIELD CONDITIONS

A. Apply coatings only when temperature of surfaces to be coated and surrounding air temperatures are between 50 and 95 deg F.

B. Do not apply coatings when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

C. Do not apply exterior coatings in snow, rain, fog, or mist.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Tenemec or comparable product by one of the following:
   1. Benjamin Moore & Co.
   2. ICI Paints.
   3. PPG Architectural Finishes, Inc.
   4. Sherwin-Williams Company (The).
   5. Refer to Finish Schedule on Drawings for Paint Types P-4 and P-5.
      a. NOTE: Paint Types P-1 through P-3 and P-6 through P-10 are described in Div 09 Section “Interior Painting” and listed on the Finish Schedule.

B. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to products listed in other Part 2 articles for the paint category indicated.
   1. Tnemec Series 90-97 Primer (Exterior Only)
   2. Tnemec Series L69 Intermediate Coat (Exterior Only – Interior Prime Coat Changed 12.23 to eliminate need for sandblasting)
   3. Tnemec Fluoronar Series 1071V (Exterior and Interior Top Coat)
   4. Tnemec Omnithane Series 1 (Interior Prime Coat)

2.2 HIGH-PERFORMANCE COATINGS, GENERAL

A. MPI Standards: Provide products that comply with MPI standards indicated and are listed in "MPI Approved Products List."

B. Material Compatibility:
   1. Provide materials for use within each coating system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.

2. For each coat in a coating system, provide products recommended in writing by manufacturers of topcoat for use in coating system and on substrate indicated.
3. Provide products of same manufacturer for each coat in a coating system.

C. VOC Content: Products shall comply with VOC limits of authorities having jurisdiction and, for interior coatings applied at project site, the following VOC limits, exclusive of colorants added to a tint base, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
1. Flat Paints and Coatings: 50 g/L.
2. Nonflat Paints and Coatings: 150 g/L.
3. Primers, Sealers, and Undercoaters: 200 g/L.
4. Anti-Corrosive and Anti-Rust Paints Applied to Ferrous Metals: 250 g/L.
5. Zinc-Rich Industrial Maintenance Primers: 340 g/L.
6. Pre-Treatment Wash Primers: 420 g/L.
7. Floor Coatings: 100 g/L.
8. Shellacs, Clear: 730 g/L.
9. Shellacs, Pigmented: 550 g/L.

D. Colors: As selected by Architect from manufacturer's full range.

2.3 INTERIOR PRIMERS/SEALERS

A. Primer Sealer, Latex, Interior: MPI #50.

2.4 EPOXY COATINGS

A. Epoxy, High-Build, Low Gloss (eggshell): MPI #108.

2.5 SOURCE QUALITY CONTROL

A. Testing of Coating Materials: Owner reserves the right to invoke the following procedure:
1. Owner will engage the services of a qualified testing agency to sample coating materials. Contractor will be notified in advance and may be present when samples are taken. If coating materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
2. Testing agency will perform tests for compliance with product requirements.
3. Owner may direct Contractor to stop applying paints if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying coating materials from Project site, pay for testing, and recoat surfaces coated with rejected materials. Contractor will be required to remove rejected materials from previously coated surfaces if, on recoating with complying materials, the two coatings are incompatible.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
1. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
   a. Gypsum Board: 12 percent.

B. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.

C. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.

D. Proceed with coating application only after unsatisfactory conditions have been corrected.
   1. Beginning coating application constitutes Contractor's acceptance of substrates and conditions.

3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
   1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection.

C. Clean substrates of substances that could impair bond of coatings, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
   1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce coating systems indicated.

3.3 APPLICATION

A. Apply high-performance coatings according to manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual."
   1. Use applicators and techniques suited for coating and substrate indicated.
   2. Coat surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, coat surfaces behind permanently fixed equipment or furniture with prime coat only.
   3. Coat back sides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
   4. Do not apply coatings over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.

B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of the same material are to be applied. Tint undercoats to match color of finish coat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.

C. If undercoats or other conditions show through final coat, apply additional coats until cured film has a uniform coating finish, color, and appearance.

D. Apply coatings to produce surface films without cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections. Produce sharp glass lines and color breaks.

3.4 FIELD QUALITY CONTROL

A. Dry Film Thickness Testing: Owner will engage the services of a qualified testing and inspecting agency to inspect and test coatings for dry film thickness.
   1. Contractor shall touch up and restore coated surfaces damaged by testing.
   2. If test results show that dry film thickness of applied coating does not comply with coating manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with coating manufacturer's written recommendations.

3. Steel surface: ASTM D4138 Standard Test Method for Measurement of Dry Film Thickness of Protective Coatings Systems by Destructive Means.
    a. Perform 3 tests at random intervals

3.5 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing coating application, clean spattered surfaces. Remove spattered coatings by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from coating operation. Correct damage by cleaning, repairing, replacing, and recoating, as approved by Architect, and leave in an undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced coated surfaces.
    a. Prime Coat: Epoxy, gloss, MPI #77.
    b. Intermediate Coat: Epoxy, gloss, MPI #77.
    c. Topcoat: Epoxy, gloss, MPI #77.

3.6 INTERIOR HIGH-PERFORMANCE COATING SCHEDULE

A. Gypsum Board Substrates:
    1. Epoxy System:
        a. Prime Coat: Primer sealer, latex, interior, MPI #50.
        b. Intermediate Coat: Epoxy, gloss, MPI #77.
        c. Topcoat: Epoxy, gloss, MPI #77.

END OF SECTION

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SECTION 09 96 46

INTUMESCENT PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes surface preparation and application of fire-retardant intumescent paint to interior items and surfaces.

B. Related Sections:
1. Section 09 91 13 "Exterior Painting" for primers, finish coats, and wood stains that may be used with intumescent paint finishes.
2. Section 09 91 23 "Interior Painting" for primers, finish coats, and wood stains that may be used with intumescent paint finishes.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.
1. Product List: Cross-reference to coating system and locations of application areas. Use same designations indicated on Drawings and in schedules. Include manufacturer's recommended spreading rate for each separate coat for each type of substrate indicated.
2. Printout of current "MPI Approved Products List" for each product category specified in Part 2 that specifies coatings approved by MPI, with the proposed product highlighted.

B. LEED Submittals:
1. Product Data for Credit IEQ 4.2: For interior paints and coatings, documentation including printed statement of VOC content.

C. Samples for Initial Selection: For each intumescent paint finish indicated.

D. Samples for Verification: For each type of coating system and each color and gloss of intumescent paint finish indicated.
1. Submit Samples on actual substrate, not less than 8 inches square.
2. Step coats on Samples to show each coat required for system.
3. Label each coat of each Sample.
4. Label each Sample for location and application area.

1.4 INFORMATIONAL SUBMITTALS

A. Material Test Reports: For each intumescent paint.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that are from same production run (batch mix) as materials applied and that are packaged with protective covering for storage and identified with labels describing contents.
1. Quantity: Furnish an additional 5 percent of each color applied, but not less than 1 gal. of each material and color applied.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain each paint system from single source from single manufacturer or provide a system approved in writing by intumescent paint manufacturer.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 450 or less.

C. MPI Standards: Comply with indicated requirements for the following:
   1. Products: MPI standards indicated and listed in "MPI Approved Products List."
   2. Preparation and Workmanship: "MPI Architectural Painting Specification Manual" for products and paint systems indicated.

D. Preinstallation Conference: Conduct conference at Project site.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.
   1. Maintain containers in clean condition, free of foreign materials and residue.
   2. Remove rags and waste from storage areas daily.

1.8 PROJECT CONDITIONS

A. Apply waterborne intumescent paints only when temperatures of surfaces to be painted and ambient air temperatures are between 50 and 90 deg F.

B. Apply solvent-thinned intumescent paints only when temperatures of surfaces to be painted and ambient air temperatures are between 45 and 95 deg F.

C. Do not apply intumescent paints in snow, rain, fog, or mist; when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

D. Allow wet surfaces to dry thoroughly and to attain temperature and conditions specified before starting or continuing coating operation.

PART 2 - PRODUCTS

2.1 INTUMESCENT PAINT MATERIALS, GENERAL

A. Location of Intumescent paint systems are indicated on the Structural Drawings.

B. Material Compatibility:
   1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
   2. For each material or coat, provide products and spreading rates recommended in writing by intumescent paint manufacturer for use on substrate indicated. Comply with requirements for fire-retardant coating classification and surface-burning characteristics indicated.

C. VOC Content: Products shall comply with VOC limits of authorities having jurisdiction and, for interior paints and coatings applied at Project site, the following VOC limits, exclusive of colorants added to a tint base, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   1. Flat Paints and Coatings: 50 g/L.
   2. Nonflat Paints and Coatings: 150 g/L.
   3. Primers, Sealers, and Undercoaters: VOC not more than 200 g/L.
   4. Anticorrosive and Antirust Paints Applied to Ferrous Metals: 250 g/L.

D. Colors and Gloss: As selected by Architect from manufacturer's full range.

2.2 INTERIOR, PIGMENTED, INTUMESCENT PAINT SYSTEM

A. Primer: Intumescent paint manufacturer's recommended primer compatible with substrate and other materials indicated.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Albi Manufacturing, a division of StanChem, Inc.; primer approved by Albi.
      b. Benjamin Moore & Co.; Fresh Start 217 Alkyd Enamel Underbody or Super Spec C245 Alkyd Enamel Undercoater/Primer Sealer.
      c. Fire Research Laboratories/Ocean Fire Retardants Inc.; latex primer approved by manufacturer.
      d. Flame Control Coatings, LLC; No. 3001 Primer.
      e. International Fire Resistant Systems, Inc.; primer approved by manufacturer.
      f. Magna Coatings Technology Inc.; no coating required.
      g. Muralo Company (The); no coating required.
      h. NoFire Technologies, Inc.; primer approved by manufacturer.
      i. PPG Industries, Inc.; Speed Hide 6-6 interior quick-drying enamel undercoater.

B. Fire-Retardant Intumescent Paint: Water-based, latex-type, fire-retardant paint for interior wood and other combustible surfaces; MPI #64.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Benjamin Moore & Co.; M59 220.
      b. Flame Control Coatings, LLC; No. 20-20; flat finish.
      c. Magna Coatings Technology Inc.; SafeCoat 451.
      d. Muralo Company (The); 1500; flat finish.
      e. NoFire Technologies, Inc.; A-18; flat finish.
      f. PPG Industries, Inc.; Speed Hide 42-7; flat finish.
   2. VOC Content: E Range of E1.

C. Topcoat/Overcoat: Water-based, latex-type, pigmented, fire-inert, protective-finish coating that will not affect fire-retardant class of intumescent coating; MPI #67.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Flame Control Coatings, LLC; no coating required.
      b. Benjamin Moore & Co.; no coating permitted.
      c. Magna Coatings Technology Inc.; no coating recommended.
      d. Muralo Company (The); no coating required.
      e. NoFire Technologies, Inc.; latex-based coating approved by NoFire.
      f. PPG Industries, Inc.; no coating recommended.
      g. Albi Manufacturing; a division of StanChem, Inc.; Albi-Cote TC Latex Semi Gloss.
   2. VOC Content: E Range of E1.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with manufacturer's

requirements for surface treatments, shop-primed surfaces, maximum moisture content, and other conditions affecting performance of the Work.

B. Begin coating only when moisture content of wood substrate is 15 percent or less when measured with an electronic moisture meter.

C. Begin coating no sooner than 28 days after substrate is constructed and is visually dry on both sides.

D. Verify suitability of substrates, including surface conditions, and compatibility with existing finishes and primers.

E. Begin coating application only after unsatisfactory conditions have been corrected and surfaces are dry.

3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations in the "MPI Architectural Painting Specification Manual" applicable to substrates and coating systems indicated.

B. Remove hardware and hardware accessories, plates, machined surfaces, light fixtures, and similar items already installed that are not to be coated. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and coating.
   1. After completing coating operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.

C. Clean substrates of substances, including dirt, oil, grease, and incompatible paints and encapsulants, that could impair bond of coatings. Do not coat surfaces if surface moisture content or alkalinity exceeds that permitted in manufacturer's written instructions.
   1. Remove incompatible primers, and reprime substrate with compatible primers as required to produce coating systems indicated.
   2. Perform cleaning and coating application so dust and other contaminants from cleaning process will not fall on wet, newly coated surfaces.

3.3 APPLICATION

A. General: Apply intumescent paints according to manufacturer's written instructions and to comply with requirements for fire-retardant coating classification.
   1. Use equipment and techniques best suited for substrate and type of material being applied.
   2. Coat surfaces behind movable items the same as similar exposed surfaces.
   3. Apply each coat separately according to manufacturer's written instructions.
   4. Finish doors on faces with intumescent finish. Paint tops, bottoms, and side edges with fire-inert finish.

B. Apply coatings to prepared surfaces as soon as practical after preparation and before subsequent surface soiling or deterioration.

C. Apply coatings to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
   1. Pigmented Finishes: If undercoats or other conditions show through pigmented topcoat/overcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.
   2. Clear Finishes: Produce a smooth surface film of even sheen using multiple coats.

3.4 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing coating application, clean spattered surfaces. Remove spattered coatings by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from coating application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

D. At completion of construction activities, touch up and restore damaged or defaced coated surfaces.

3.5 PAINT SYSTEM SCHEDULE

A. Prime Coat: If required and approved by intumescent paint manufacturer.

B. Fire-Retardant Intumescent Coating: Minimum two coats to comply with requirements for fire-retardant coating classification and surface-burning characteristics indicated.

C. Topcoat/Overcoat: Apply if required or recommended and approved by intumescent paint manufacturer.

END OF SECTION

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SECTION 101423 - INTERIOR SIGNAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Panel signs.
2. Dimensional metal letters
3. Glass
4. Vinyl graphics

1.3 DEFINITIONS

A. Accessible: In accordance with the accessibility standard.

1.4 COORDINATION

A. Furnish templates for placement of sign-anchorage devices embedded in permanent construction by other installers.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For interior signs.
1. Include fabrication and installation details and attachments to other work.
2. Show sign mounting heights, locations of supplementary supports to be provided by others, and accessories.
3. Show message list, typestyles, graphic elements, including raised characters and Braille, and layout for each sign at least half size.

C. Samples for Initial Selection: For each type of sign assembly, exposed component, and exposed finish.
1. Include representative samples of available typestyles and graphic symbols.

D. Samples for Verification: For each type of sign assembly showing all components and with the required finish(es), in manufacturer's standard size unless otherwise indicated and as follows:
1. Panel Signs: Full-size Sample – Sign Type C.
2. Room-Identification Signs: Full-size Sample – Sign Type A2.
3. Field-Applied, Vinyl-Character Signs: Full-size Sample of characters on acrylic sheet.
4. Variable Component Materials: Full-size Sample of each base material, character (letter, number, and graphic element) in each exposed color and finish not included in Samples above: Aluminum Letter, and Dichroic Glass with etched and painted graphic.
5. Exposed Accessories: Full-size Sample of each accessory type, including steel memo clip.

E. Sign Schedule: Use same designations specified or indicated on Drawings or in a sign schedule. Generate Interior Sign Message Schedule listing all graphics and sign messages for Owner approval prior to fabrication. Owner shall have the right to revise the messages through the shop drawing approval process.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and manufacturer.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For signs to include in maintenance manuals.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Accuracy of message translation into Grade II Braille is the responsibility of the Signage Contractor.

C. Details shown on the drawings shall be followed for visual appearance**.**

1.9 FIELD CONDITIONS

A. Field Measurements: Verify locations of anchorage devices embedded in permanent construction by other installers by field measurements before fabrication, and indicate measurements on Shop Drawings.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of signs that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Deterioration of finishes beyond normal weathering.
      b. Deterioration of embedded graphic image.
      c. Separation or delamination of sheet materials and components.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANEL SIGNS, GENERAL

A. Regional Materials: Panel signs shall be manufactured within 500 miles of Project site.

2.2 PERFORMANCE REQUIREMENTS

A. Thermal Movements: For exterior signs, allow for thermal movements from ambient and surface temperature changes.
   1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

B. Accessibility Standard: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities and ICC A117.1 for signs.

2.3 SIGNS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated or comparable product by one of the following:

1. Ace Sign Systems, Inc.
2. Advance Corporation; Braille-Tac Division.
3. APCO Graphics, Inc.
4. ASI Sign Systems, Inc.
5. Best Sign Systems Inc.
6. Bunting Graphics, Inc.
7. Clarke Systems.
8. Diskey Sign Company.
9. InPro Corporation.
10. Nelson-Harkins Industries.
11. Poblocki Sign Company, LLC.

C. Sign Messages: Signage Contractor to generate and verify final list of sign messages with Owner prior to fabrication of signs. Furnish insert paper material perforated or with cut delineations in printing layout for changeable message inserts. Provide printed inserts for scheduled messages; provide blank sheet where message is yet to be determined. Provide electronic printing layout template for creating text and symbols for PC-Windows computers for Owner future production of paper inserts.

D. Panel Sign: Sign with smooth, uniform surfaces; with message and characters having uniform faces, sharp corners, and precisely formed lines and profiles; and as follows:
1. Basis-of-Design Product: Indicated on Drawings.
2. Laminated Plastic-Sheet Sign: Plastic face sheet laminated to plastic base sheet to produce composite sheet.
   a. Composite-Sheet Thickness: Manufacturer's standard for size of sign.
   b. Subsurface Graphics: Reverse silkscreen or vinyl image.
3. Sign-Panel Perimeter: Finish edges smooth.
   a. Edge Condition, Vertical Edges
   b. Corner Condition in Elevation: Square.
4. Frame: None.
5. Mounting: Manufacturer's standard method for substrates indicated with concealed anchors, adhesive.
6. Surface Finish and Applied Graphics:
   a. Integral Acrylic Sheet Color: As selected by Architect from full range of industry colors.
7. Text and Typeface: Accessible raised characters and Braille typeface matching Architect's sample.
8. Flatness Tolerance: Sign panel shall remain flat or uniformly curved under installed conditions as indicated and within a tolerance of plus or minus 1/16 inch measured diagonally from corner to corner.

2.4 SIGN MATERIALS

A. Steel Materials:
1. Steel Memo Clip: Stainless steel clip with ball bearing to hold paper memo, as manufactured by Prodyne, Rancho Cucamonga, CA, 909-484-1212, www.prodyne.com.

B. Acrylic Sheet: Cast methyl methacrylate monomer plastic sheet, in sizes and thickness indicated, with a minimum allowable continuous service temperature of 176 degrees F (80 degrees C), and of transparent and or opaque sheet as specified.

C. Polycarbonate Sheet: ASTM C 1349, Appendix X1, Type II (coated, mar-resistant, UV-stabilized polycarbonate), with coating on both sides.

D. Acceptable manufacturers include: Plexiglass (Rohm and Haas Co.); Lexan (General Electric Co.);

Acrylite (Cyro).

E. Vinyl Film

1. Provide translucent or opaque non-reflective vinyl film as specified, 2-mil minimum thickness, with pressure sensitive adhesive backing, suitable for interior applications.

2. Legends shall securely adhere when subjected to any temperature within the range of minus 30 degrees F (-34 degrees C) to 200 degrees F (93 degrees C) and shall not crack, chip or peel voluntarily.

3. Shrinkage of letters shall not exceed 1/64 inch (0.4 MM) in any direction.

4. Acceptable products are:
   a. 3M's "Scotchcal"
   b. Gerber Vinyl Film
   c. Avery Dennison's "Fasson 1000 series Premium Vinyl"

2.5 ACCESSORIES

A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of signage, noncorrosive and compatible with each material joined, and complying with the following:
   1. Use concealed fasteners and anchors unless indicated to be exposed.
   2. Exposed Metal-Fastener Components, General:
      a. Fabricated from same basic metal and finish of fastened metal unless otherwise indicated.
      b. Fastener Heads: For nonstructural connections, use flathead screws and bolts with tamper-resistant Allen-head or one-way-head slots unless otherwise indicated.
   3. Sign Mounting Fasteners:
      a. Concealed Studs: Concealed (blind), threaded studs welded or brazed to back of sign material or screwed into back of sign assembly, unless otherwise indicated.
      b. Projecting Studs: Threaded studs with sleeve spacer, welded or brazed to back of sign material or screwed into back of sign assembly, unless otherwise indicated.
   ~~4.~~ Inserts: Furnish inserts to be set by other trades into concrete or masonry work.

2.6 DIMENSIONAL LETTERS

A. Provide cast or cut out clear aluminum characters, of the size and thickness and finish specified. Cut out letters shall be cut from flat bar stock. Use template to pin-mount letters plumb and even, flush to wall surface. Provide matching aluminum backup on opposite surface, where mounted on glass.

2.7 GLASS

A. Dichroic laminated glass: Two layers of safety laminated glass with dichroic inter-layer, and etched finish on face. Applied graphics are surface etched and painted.

B. Acceptable manufacturers: Bendheim Glass/www.bendheim.com, or as approved.

2.8 FABRICATION

A. General: Provide manufacturer's standard sign assemblies according to requirements indicated.
   1. Preassemble signs and assemblies in the shop to greatest extent possible. Disassemble signs and assemblies only as necessary for shipping and handling limitations. Clearly mark units for reassembly and installation; apply markings in locations concealed from view after final assembly.
   2. Mill joints to a tight, hairline fit. Form assemblies and joints exposed to weather to resist water penetration and retention.

3. Comply with AWS for recommended practices in welding and brazing. Provide welds and brazes behind finished surfaces without distorting or discoloring exposed side. Clean exposed welded and brazed connections of flux, and dress exposed and contact surfaces.
4. Conceal connections if possible; otherwise, locate connections where they are inconspicuous.
5. Internally brace signs for stability and for securing fasteners.
6. Provide rebates, lugs, and brackets necessary to assemble components and to attach to existing work. Drill and tap for required fasteners. Use concealed fasteners where possible; use exposed fasteners that match sign finish.

B. Signs with Changeable Message Capability: Fabricate signs to allow insertion of changeable messages as follows:
1. For slide-in changeable inserts, fabricate slot without burrs or constrictions that inhibit function. Furnish initial changeable insert. Subsequent changeable inserts are by Owner. Furnish electronic template in word processing program for future insert printing by Owner.

2.9 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

C. Directional Finishes: Run grain with long dimension of each piece and perpendicular to long dimension of finished trim or border surface unless otherwise indicated.

D. Organic, Anodic, and Chemically Produced Finishes: Apply to formed metal after fabrication but before applying contrasting polished finishes on raised features unless otherwise indicated.

E. Paints and inks shall be made of other surface material on which they are to be applied and as recommended by the manufacturer of the paint or ink. Identification of paint or ink shall be noted on shop drawings with method of application. Prime coats or other surface pre-treatments, where recommended, shall be included in the work. Coating shall be even over entire surface to be painted, without voids, runs, sags, brush or roller marks.

F. In general, paint application shall be by brush or airless spray. Paint applied by brush shall be free of objectionable brush marks and meet the approval of the Owner.

G. Interior paint finishes shall be acrylic polyurethane. Acrylic Polyurethane finish shall be applied at the rate of 2.5 mils per coat by air or airless spray.

H. Acceptable manufacturers include:
1. Matthews Paint Co.
2. Akzo Coatings Inc.
3. Spraylat Corporation

I. Interior paint finishes shall be satin matte.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for

installation tolerances and other conditions affecting performance of signage work.

B. Verify that sign-support surfaces are within tolerances to accommodate signs without gaps or irregularities between backs of signs and support surfaces unless otherwise indicated.

C. Verify that anchor inserts are correctly sized and located to accommodate signs.

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

3.2 INSTALLATION

A. General: Install signs using mounting methods indicated and according to manufacturer's written instructions.
   1. Install signs level, plumb, true to line, and at locations and heights indicated, with sign surfaces free of distortion and other defects in appearance.
   2. Install signs so they do not protrude or obstruct according to the accessibility standard.
   3. Before installation, verify that sign surfaces are clean and free of materials or debris that would impair installation.

B. Mounting Methods:
   1. Concealed Studs: Using a template, drill holes in substrate aligning with studs on back of sign. Remove loose debris from hole and substrate surface.
      a. Masonry Substrates: Fill holes with adhesive. Leave recess space in hole for displaced adhesive. Place sign in position and push until flush to surface, embedding studs in holes. Temporarily support sign in position until adhesive fully sets.
      b. Thin or Hollow Surfaces: Place sign in position and flush to surface, install washers and nuts on studs projecting through opposite side of surface, and tighten.
   2. Projecting Studs: Using a template, drill holes in substrate aligning with studs on back of sign. Remove loose debris from hole and substrate surface.
      a. Masonry Substrates: Fill holes with adhesive. Leave recess space in hole for displaced adhesive. Place spacers on studs, place sign in position, and push until spacers are pinched between sign and substrate, embedding the stud ends in holes. Temporarily support sign in position until adhesive fully sets.
      b. Thin or Hollow Surfaces: Place spacers on studs, place sign in position with spacers pinched between sign and substrate, and install washers and nuts on stud ends projecting through opposite side of surface, and tighten.
   3. Adhesive: Clean bond-breaking materials from substrate surface and remove loose debris. Apply linear beads or spots of adhesive symmetrically to back of sign and of suitable quantity to support weight of sign after cure without slippage. Keep adhesive away from edges to prevent adhesive extrusion as sign is applied and to prevent visibility of cured adhesive at sign edges. Place sign in position, and push to engage adhesive. Temporarily support sign in position until adhesive fully sets.
   4. Shim-Plate Mounting: Provide 1/8-inch- thick, concealed aluminum shim plates with predrilled and countersunk holes, at locations indicated, and where other direct mounting methods are impractical. Attach plate with fasteners and anchors suitable for secure attachment to substrate. Attach signs to plate using method specified above.

C. Signs Mounted on Glass: Provide opaque vinyl sheet matching sign material and finish on first surface of glass to conceal back of sign and tape mounting.

3.3 ADJUSTING AND CLEANING

A. Remove and replace damaged or deformed signs and signs that do not comply with specified requirements. Replace signs with damaged or deteriorated finishes or components that cannot be

successfully repaired by finish touchup or similar minor repair procedures.

B. Remove temporary protective coverings and strippable films as signs are installed.

C. On completion of installation, clean exposed surfaces of signs according to manufacturer's written instructions, and touch up minor nicks and abrasions in finish. Maintain signs in a clean condition during construction and protect from damage until acceptance by Owner.

D. Keep the premises free of rubbish and debris caused by this work, and upon completion of the work leave the area included in the contract dust-free and spotless clean. Vacuum up all dust at each installed sign location. Remove waste materials and debris from the site and dispose of at legal disposal area away from the site.

END OF SECTION

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TYPEFACES

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
1234567890

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
1234567890

HELVETICA - REGULAR & BOLD

TBD

WHITE

RED
PMS 485C

SIGN COLORS/FINISHES

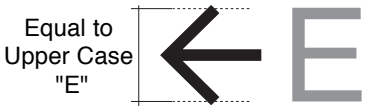
SIGN BKGRD: COLOR TBD

WHITE PAINT: MATCH MATTHEWS MAP NATURAL WHITE #42202
VINYL: 3M SCOTCHCAL 'MATTE WHITE' #7725-20

RED MATCH PMS 485C
VINYL: 3M SCOTCHCAL 'TOMATO RED' #7725-13

GREY VINYL: COLOR TBD

SYMBOLS



ARROW

RADIATION

BIOHAZARD

LASER

ACCESSIBLE

NO SMOKING

FIRE
EXTINGUISHER

MEN

WOMEN

STAIRS

COATS

COFFEE/VENDING

In Case of Fire Use Stairs
Do Not Use Elevators

NFPA #7
(IN CASE OF FIRE...)

TORNADO SHELTER

NOTES:
ELECTRONIC ARTWORK FOR SYMBOLS & LOGOS AVAILABLE FROM INKSPOT DESIGN.
DRAWINGS ARE FOR DESIGN INTENT ONLY.
FIELD VERIFY ALL DIMENSIONS & CONDITIONS.

SignTypes List

1 A1, Room ID, 4 x 9”, Rm# w/Braille, insert - small, Offices

2 A2, Room ID, 5 x 9”, Rm# w/Braille, insert - large, Offices, Labs

3 B1, Room ID, 3 x 9”, w/Braille

4 B2, Room ID, 3 x 12”, w/Braille

5 B3, EXIT, 3 x 9”, w/Braille

6 C, Restroom ID, 9X6”, Rm# w/Braille

7 D1, Room ID, 3 x 9”, Rm# w/Braille + 1 line text

8 D2, Room ID, 5 x 9”, Rm# w/Braille + 2 lines text

9 D3, Room ID, 9 x 9”, Rm# w/Braille + 3 lines text

10 E, Elevator ID, 8 x 6", subsurface

11 H, Workstation ID, 4 x 9”, Rm# w/Braille, insert, bracket

12 J - Flagmount ID, 9 x 9", symbols

13 M, Stair ID, 8 x 6", stairwells, w/Braille

14 Q, Directional wall sign, 12 x 18", vinyl letters

15 R1, NO exit, 6 x 9", w/Braille

16 S1, Message, 5 x 9", Subsurface (Author Personnel Only)

17 T, Tornado Shelter, 9 x 6", w/Braille

18 U, Max Occupancy, 3 x 9", subsurface

19 W1, Window Insert Holder, 12 x 9”, vert (8.5x11 insert at Labs)

20 W2, Window Insert Holder, 9 x 12”, horiz (8.5x11 insert-maps)

21 FE, Fire Extinguisher ID, 6 x 6", triangular flagmount in corrs

22 LTR, Alum Individual Letters (Conference Ctr)

23 VYL-1, Vinyl symbols/No Smoking at Bldg entry

24 VYL-2, Vinyl graphics at connector corr

25 GLS, Custom glass transom w/etched lettering

26 Z, Steel Memo Clip (at select offices)

27 GBU, Glass Backup - vinyl

SignType VYL-1

Sign Size
VYL-1: 3 1/2" DIA.

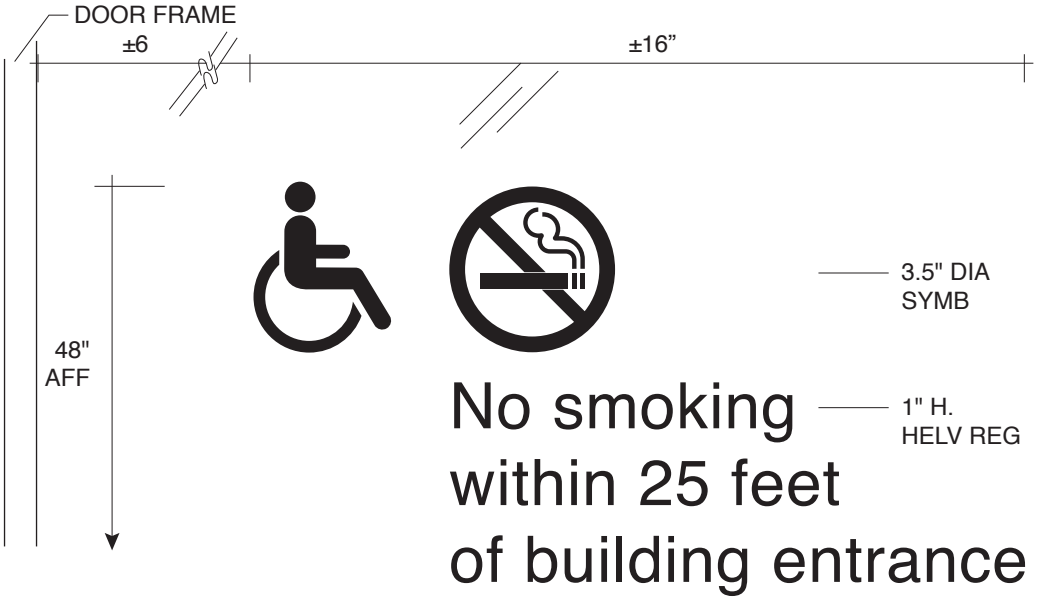
Description:
Vinyl graphics

Sign Messages
Symbol

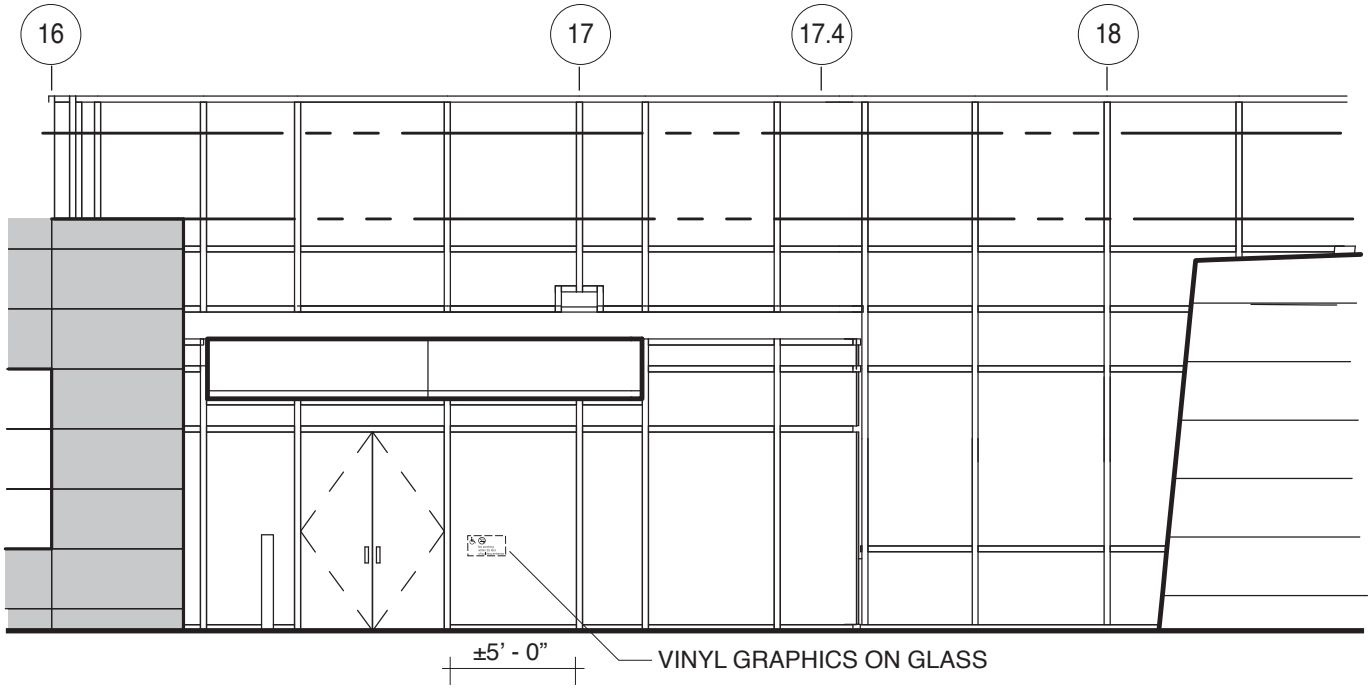
Graphic Process
Die cut vinyl graphics

Color
White

Mounting
Applied to glass, 2nd surface at building entrance.



SCALE: 3" = 1' - 0"

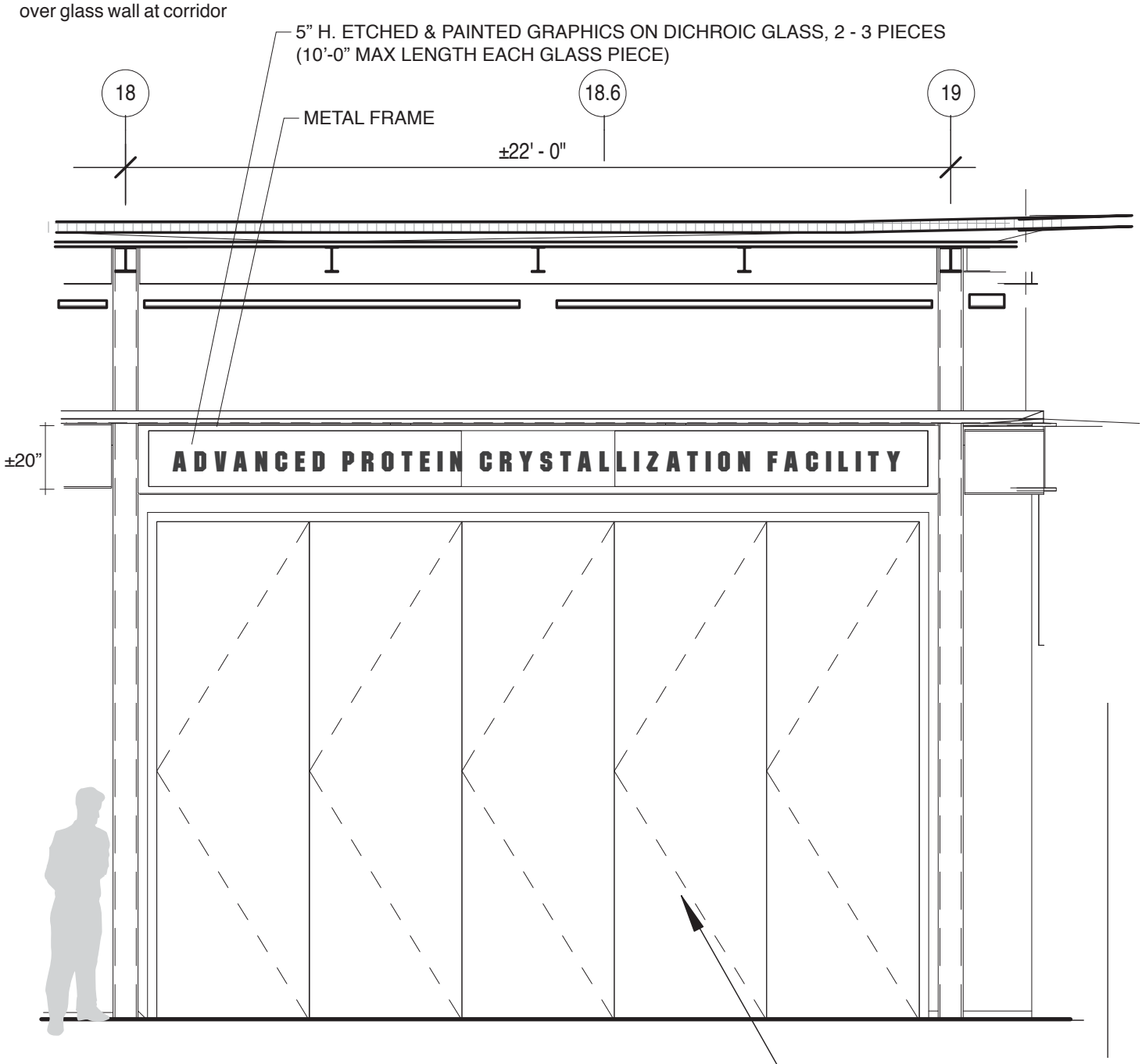


ELEVATION - EXTERIOR BLDG ENTRANCE
SCALE: 1/8" = 1'-0"

SignType GLS

Sign Size
GLS: ±20" H. x ±22'-0" L.

Description:
Etched graphics on dichroic glass, mounted into metal frame in transom over glass wall at corridor



ELEVATION - INTERIOR, NORTH CORRIDOR ELEVATION
SCALE: 1/4" = 1'-0"

SignType GLS

Sign Size
GLS: ±20" H. x ±22'-0" L.

Description
Building Name;
Etched graphics on
dichroic glass,
mounted into metal
frame in transom
over glass wall at corridor

Sign Components
Etched glass face with
dichroic interlayer,
clear glass backer,
mirror or painted back surface

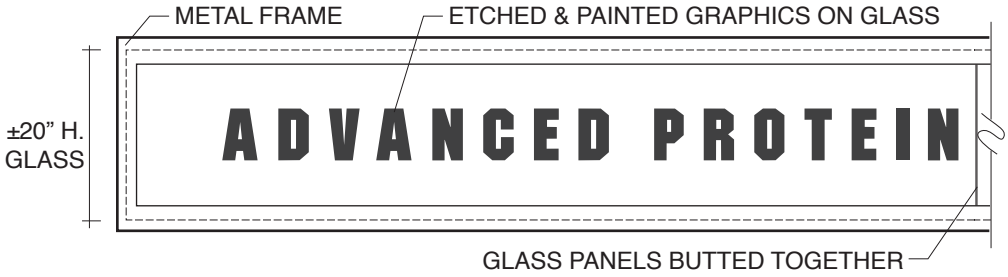
Graphic Process
Deep etched letters, ±1/16" D.
Painted, matte finish

Typography
"Pittsburgh Bold"

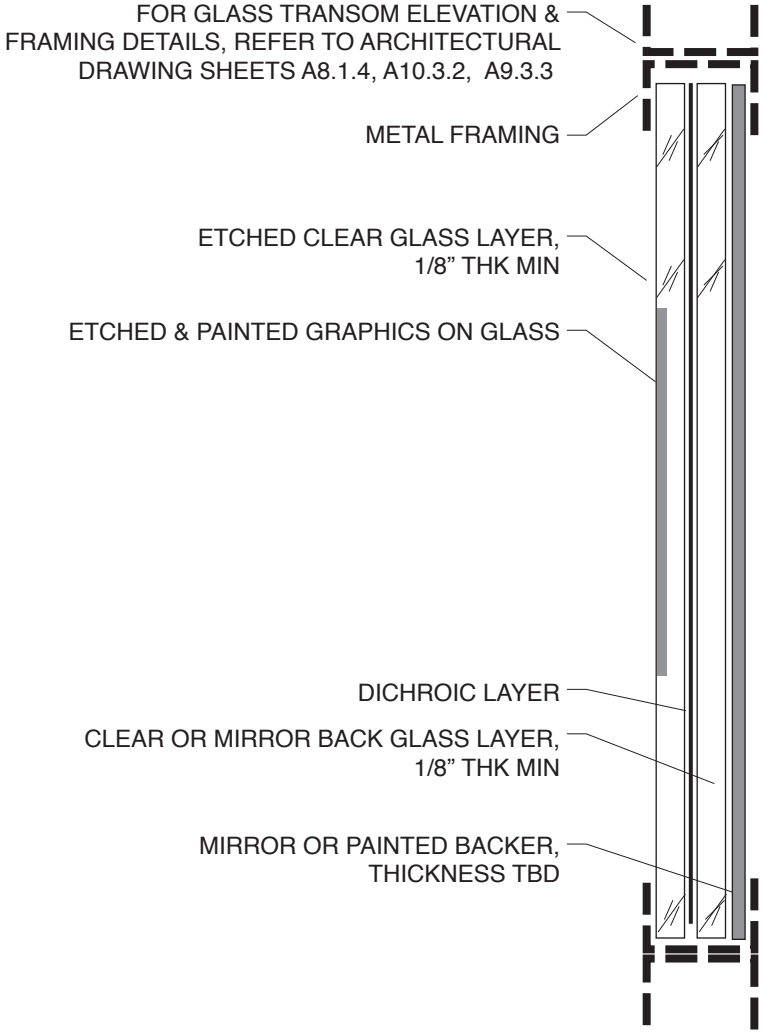
Color
Etched Graphics:
Dk Grey, Color TBD

Mounting
In metal perimeter frame.

Installation
Wall mount inside frame
within transom area.



GLASS DETAIL
SCALE: 1/2" = 1'-0"



GLASS DETAIL - AT TRANSOM
SCALE: NONE

SignType VYL-2

Sign Size
VYL-2: Custom Size

Description
Interior vinyl graphics on glass

Sign Messages
TBD

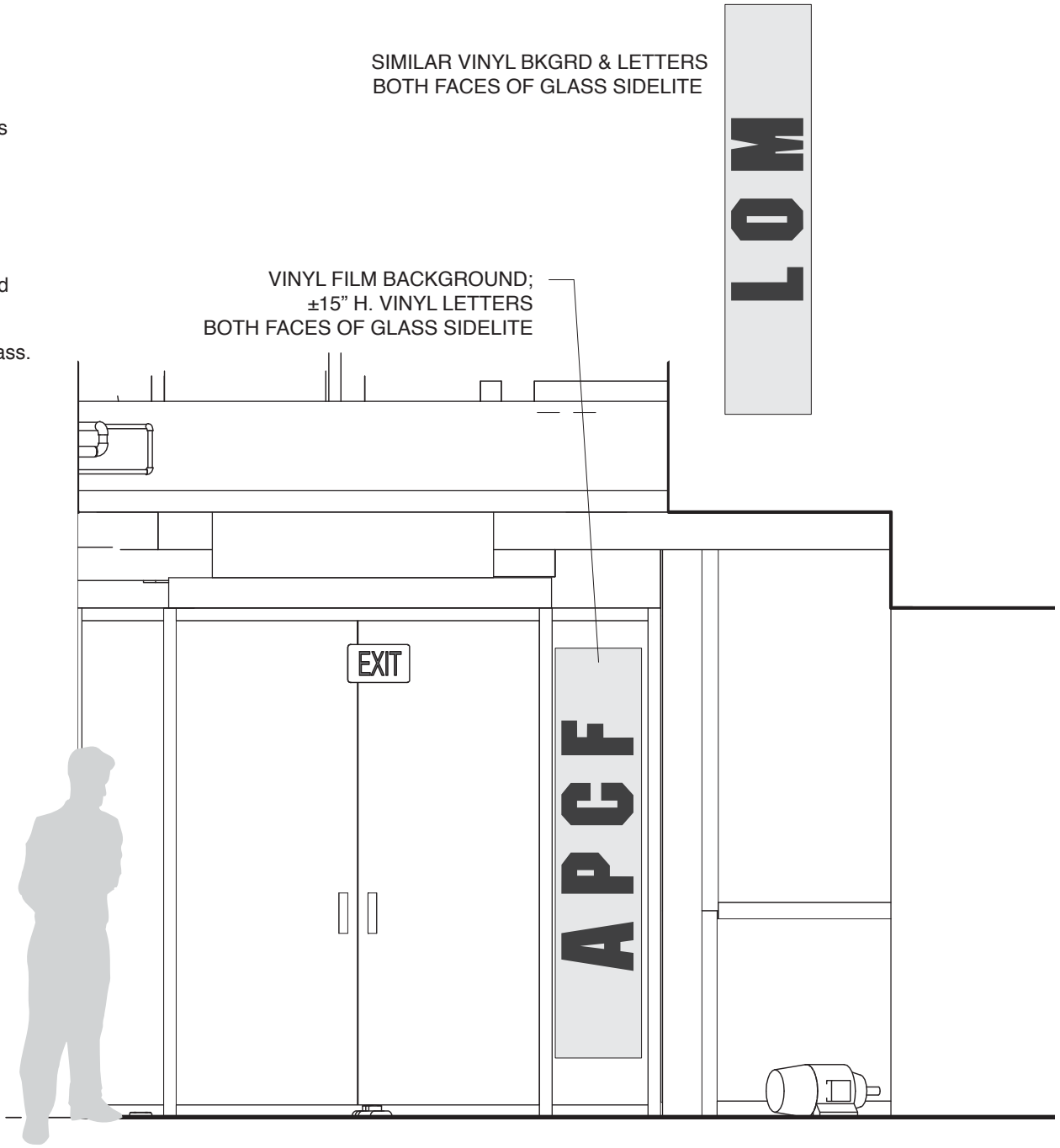
Graphic Process
Vinyl graphics on glass

Typography
Pittsburgh Bold

Color
White Vinyl Letters
Grey Vinyl Background

Mounting
Adhesive mount to glass.

Installation
Wall mount on glass sidelite, corridor connector



ELEVATION - INTERIOR, NORTH CORRIDOR ELEVATION

SCALE: 3/8" = 1' - 0"

SignType LTR

Sign Size
LTR: " H. LETTERS

Description
Cut out aluminum letters

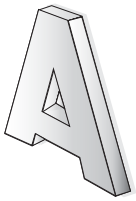
Sign Messages
As scheduled; name shown this sheet as example only.

Sign Components
1/4" D. laser or waterjet cut out aluminum letters

Typography
Pittsburgh Bold

Color
Clear aluminum, mirror-polished faces, satin returns

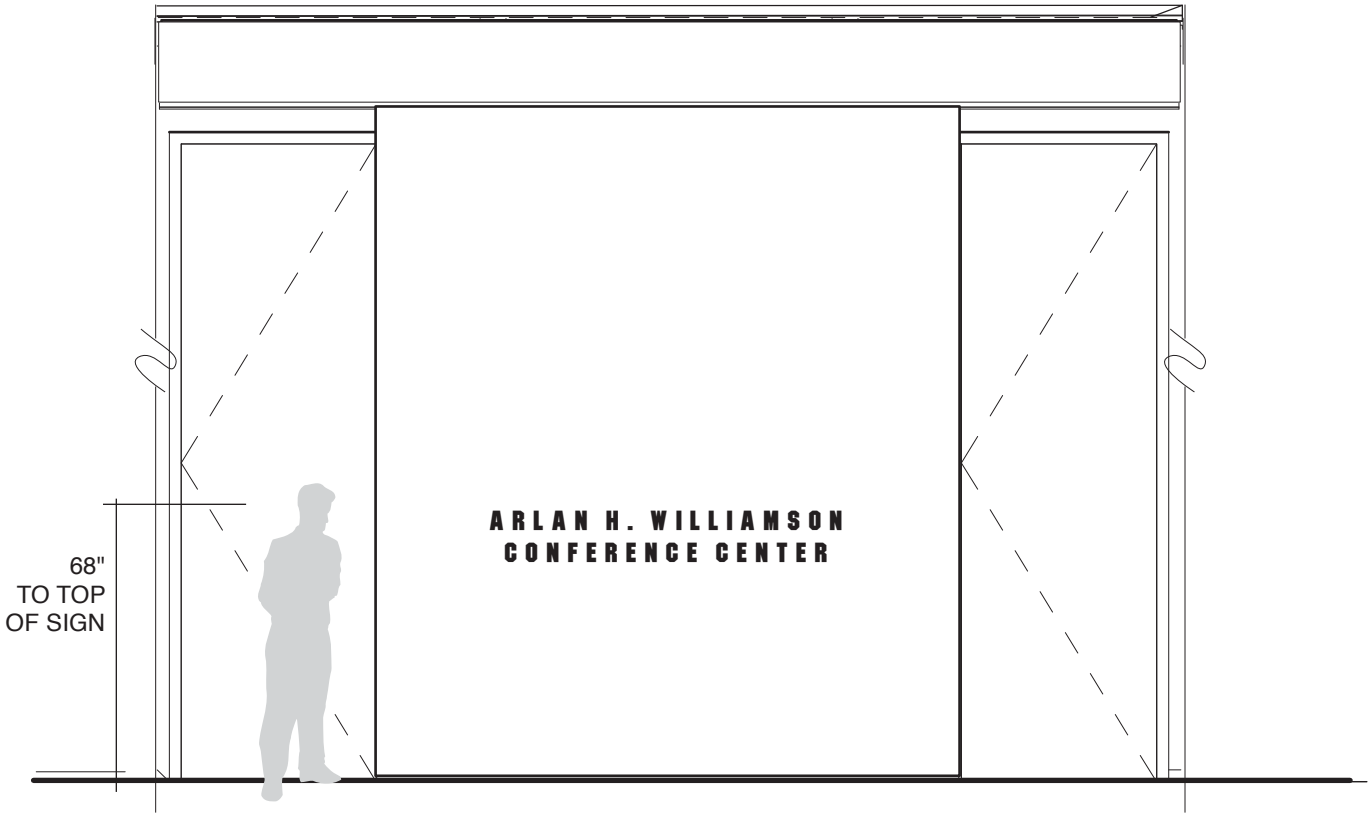
Mounting
Pin mount flush to gypboard wall



TYPESTYLE:	PITTSBURGH BOLD, U&LC
MATERIAL:	CUT OUT ALUM LETTERS
SIZE:	4" H.
THICKNESS:	1/4" D.
FINISH:	CLEAR ALUMINUM MIRROR POLISHED FINISH
MOUNTING:	STUD, FLUSH

ARLAN H. WILLIAMSON
CONFERENCE CENTER

CUT OUT ALUM LETTERS - QTY: 1 SET



ELEVATION - INTERIOR, NORTH CORRIDOR ELEVATION

SCALE: 1/4" = 1' - 0"

SignTypes A1, A2

Sign Size
4X9”, 5X9”

Description
Identification Sign

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish, subsurface painted.
Square corners.
Tactile Room Number
+ Changeable Insert

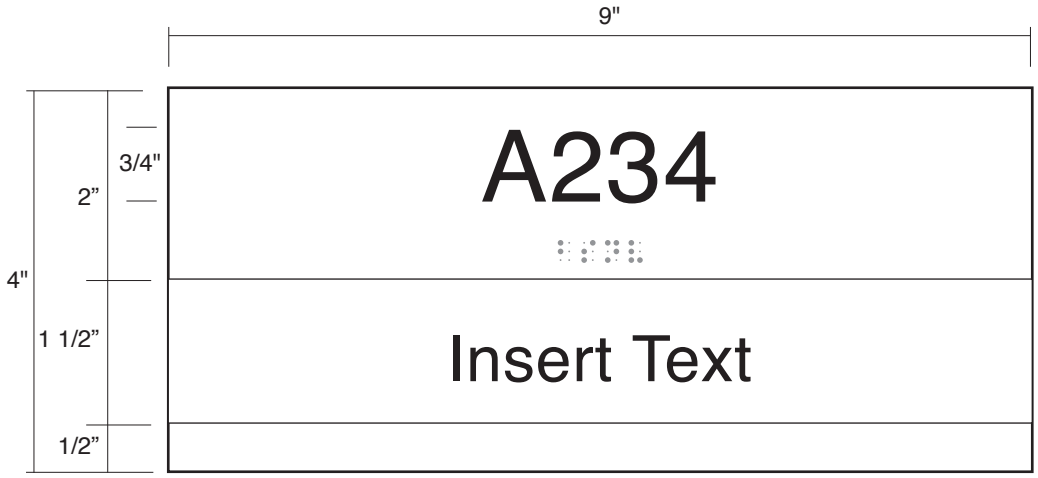
Graphic Process
Tactile cut out graphics, Grade II Braille.

Typography
Helvetica Regular

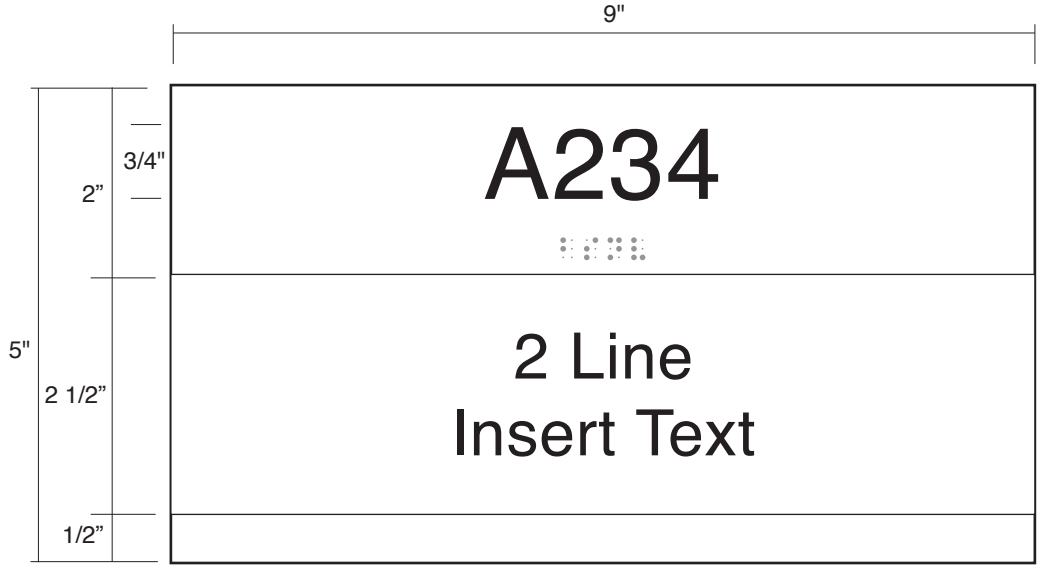
Color
Bkgrd TBD, Subsurface
Text Color - TBD
Paper Insert - White paper

Mounting
VHB tape.

Installation
Wall mount.



A1



A2

SCALE: ONE HALF FULL SIZE

SignTypes B1, B2

Sign Size
3X9”,
3X12”

Description
Identification Sign

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish,
subsurface painted.
Square corners.
Tactile text

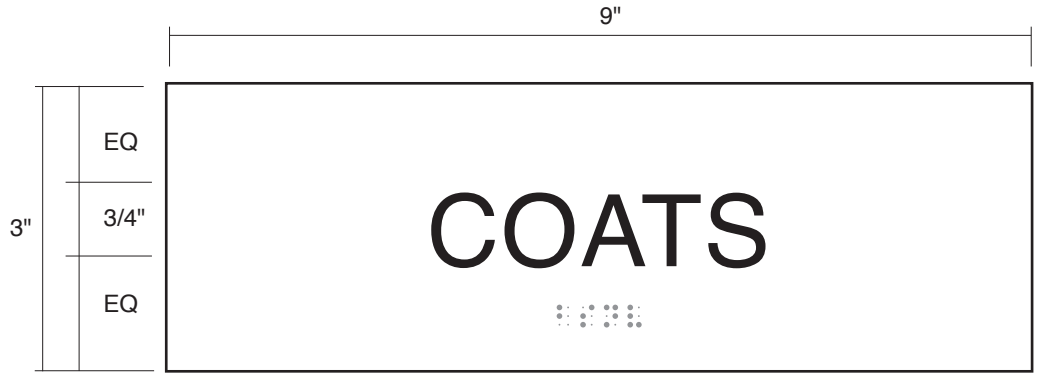
Graphic Process
Tactile cut out graphics,
Grade II Braille.

Typography
Helvetica Regular

Color
Bkgrd TBD, Subsurface
Text Color - TBD

Mounting
VHB tape.

Installation
Wall mount



B1

B1 EXAMPLE - ROOM NUMBER

B2

B2 EXAMPLE - ROOM NUMBERS RANGE

SCALE: ONE HALF FULL SIZE

SignType B3

Sign Size
3X9”

Description
Tactile Exit Sign

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish,
subsurface painted.
Square corners.
Tactile text

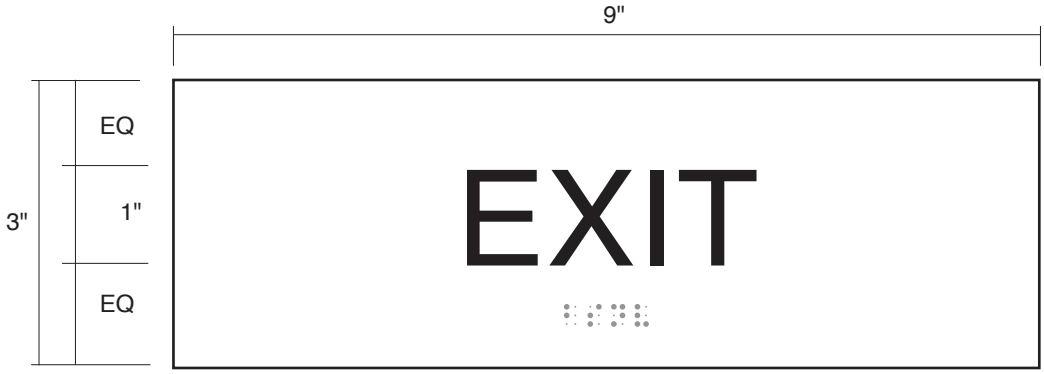
Graphic Process
Tactile cut out graphics,
Grade II Braille.

Typography
Helvetica Regular

Color
Bkgrd TBD, Subsurface
Text Color - TBD

Mounting
VHB tape.

Installation
Wall mount at exit
door of building



B3

SCALE: ONE HALF FULL SIZE

SignType C - Restroom ID

Sign Size
9x6”

Description
Identification Sign - Restrooms

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish,
subsurface painted.
Square corners.
Tactile text

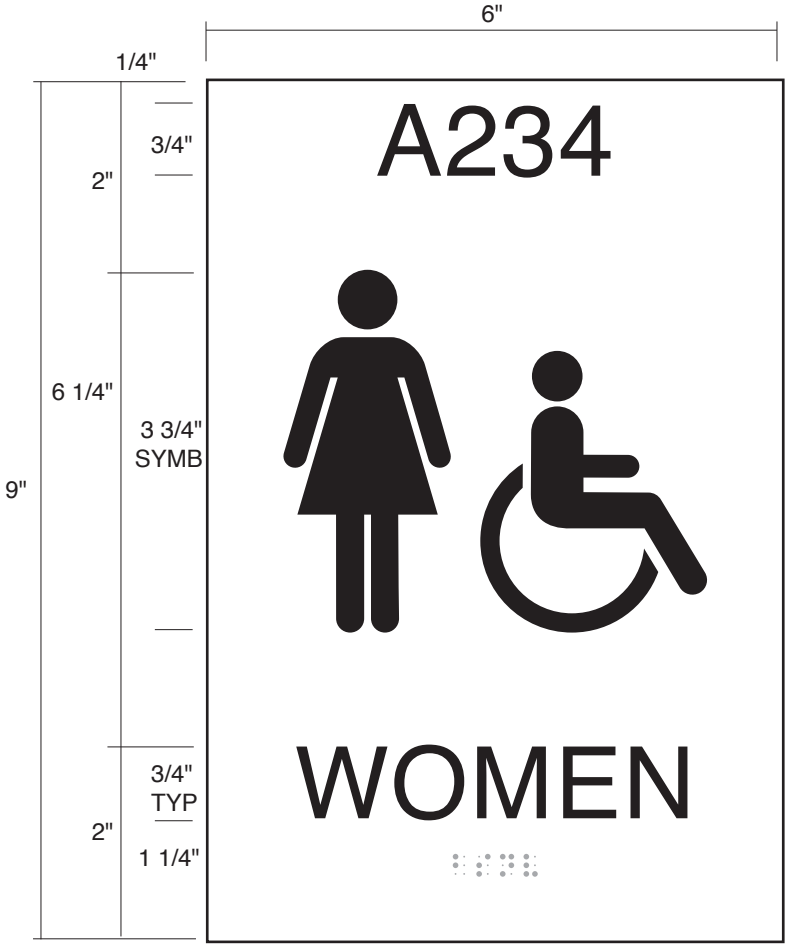
Graphic Process
Tactile cut out graphics,
Grade II Braille.

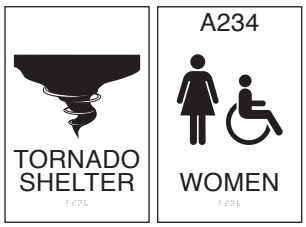
Typography
Helvetica Regular

Color
Bkgrd TBD, Subsurface
Text Color - TBD

Mounting
VHB tape.

Installation
Wall mount





MOUNT RESTROOM & TORNADO
SIGNS NEXT TO EACH OTHER
WHERE NOTED

SCALE: ONE HALF FULL SIZE

SignTypes D1, D2

Sign Sizes
3x9”, 5x9”

Description
Identification Sign

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish, subsurface painted.
Square corners.
Tactile text

Graphic Process
Tactile cut out graphics, Grade II Braille.

Typography
Helvetica Regular

Color
Bkgrd TBD, Subsurface
Text Color - TBD

Mounting
VHB tape.

Installation
Wall mount

D1 - ROOM # + 1 LINE TEXT

D2 - ROOM # + 2 LINES TEXT

SCALE: ONE HALF FULL SIZE

SignType D3

Sign Size
9x9”

Description
Identification Sign

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish, subsurface painted.
Square corners.
Tactile text

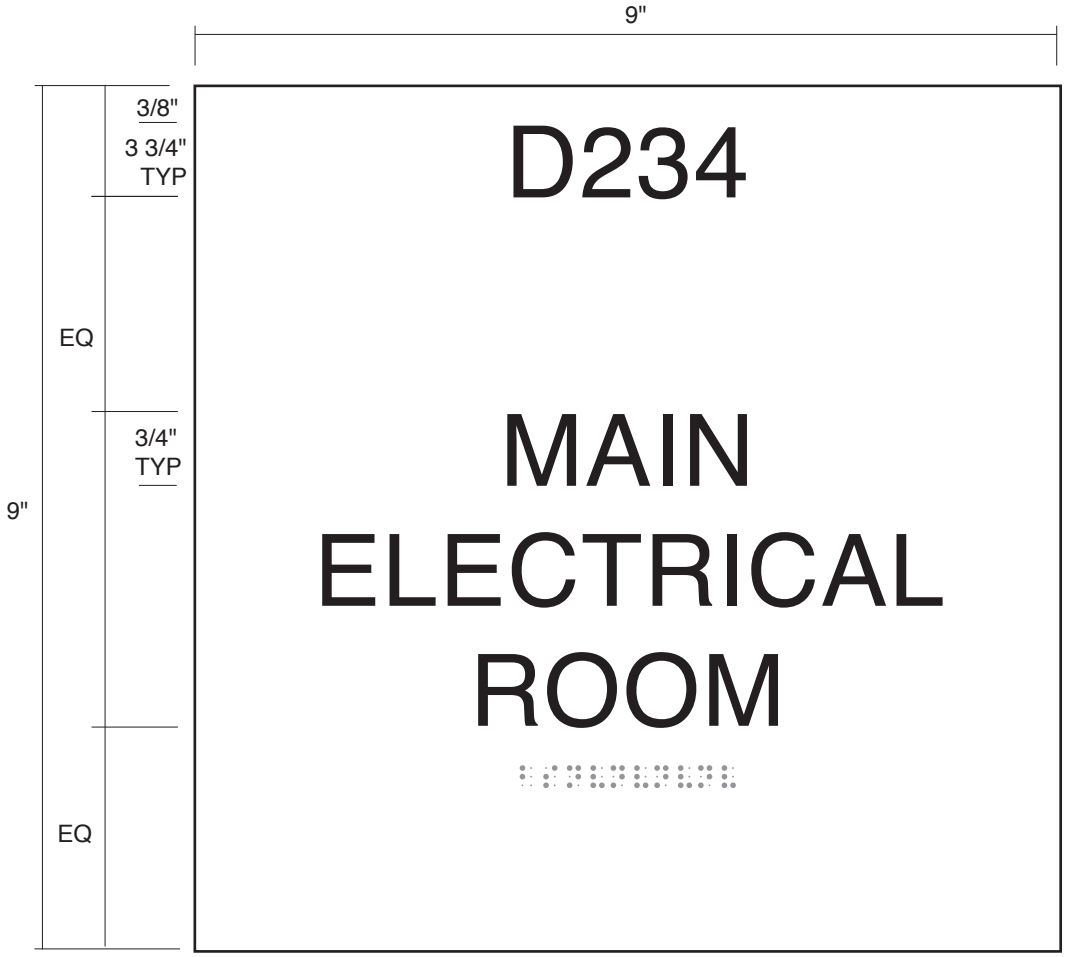
Graphic Process
Tactile cut out graphics, Grade II Braille.

Typography
Helvetica Regular

Color
Bkgrd TBD, Subsurface
Text Color - TBD

Mounting
VHB tape.

Installation
Wall mount



D3 - ROOM # + 3 OR 4 LINES TEXT

EXAMPLE - TYP FOR
CONFERENCE RMS

SCALE: ONE HALF FULL SIZE

SignType E

Sign Size
8x6”

Description
Identification Sign

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish,
subsurface painted.
Square corners.

Graphic Process
Subsurface graphics

Typography
Helvetica Regular

Color
Bkgrd TBD, Subsurface
Text Color - TBD

Mounting
VHB tape.

Installation
Wall mount at elevator

SCALE: ONE HALF FULL SIZE

SignType H - Workstations

Sign Size
4X9”

Description
Identification Sign

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish, subsurface painted.
Square corners.
Tactile Room Number
+ Changeable Insert

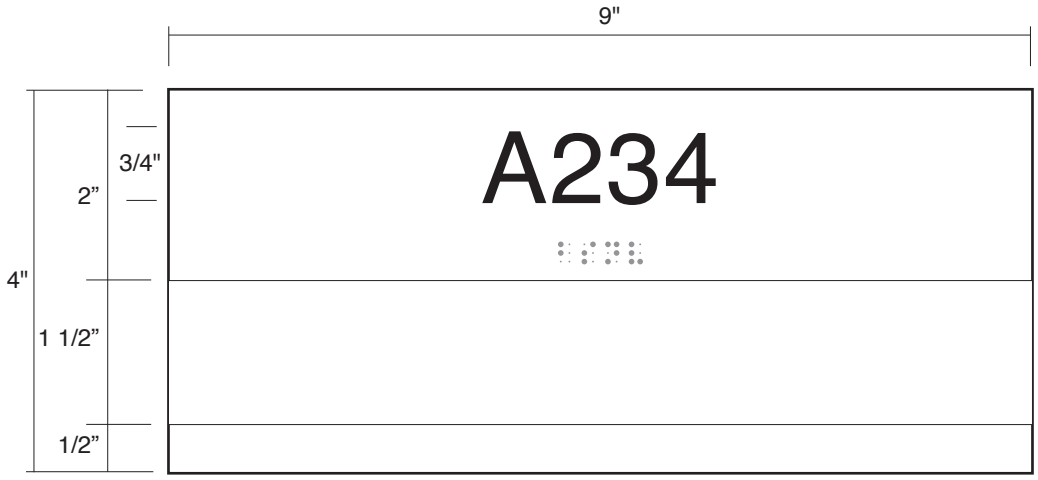
Graphic Process
Tactile cut out graphics, Grade II Braille.

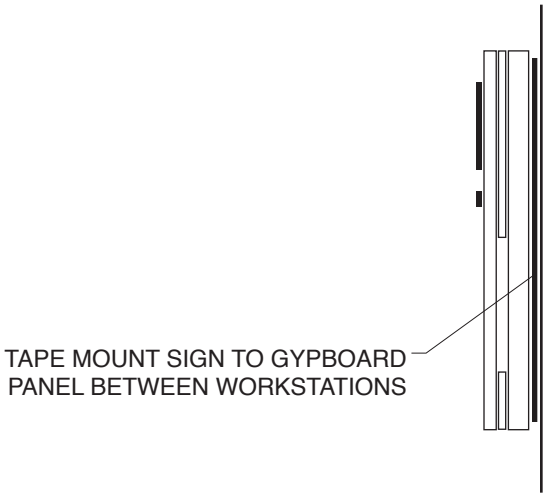
Typography
Helvetica Regular

Color
Bkgrd TBD, Subsurface
Text Color - TBD
Paper Insert - White paper

Mounting
VHB tape.

Installation
Mount to painted gypboard divider panel at open office workstations.





SCALE: ONE HALF FULL SIZE

SignType J - Flagmount

Sign Size
9X9”

Description
Flagmount Amenities Identification Sign, Doubleface

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish, subsurface painted background color. Square corners.

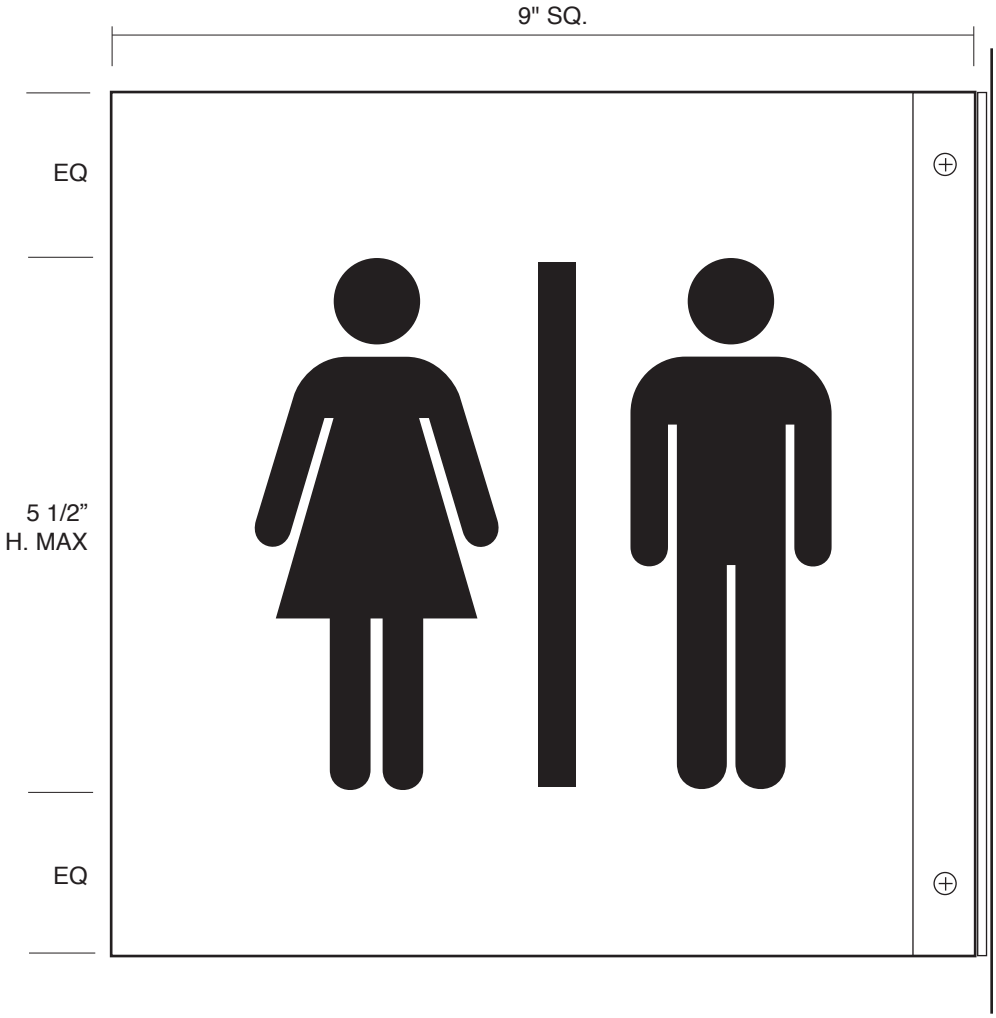
Graphic Process
Surface applied vinyl graphics

Typography
NA - Symbols Only

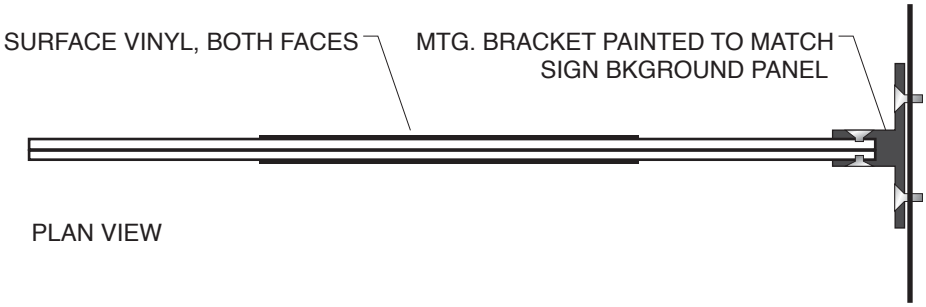
Color
Bkgrd Color - TBD, Subsurface
Text Color - TBD

Mounting
Bracket, mechanical fasteners

Installation
Bracket mount perpendicular to wall



EXAMPLE - BREAK ROOMS



PLAN VIEW

SCALE: ONE HALF FULL SIZE

SignType M - Stair ID

Sign Size
8x6”

Description
Identification Sign - Stairs

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish,
subsurface painted.
Square corners.
Tactile text

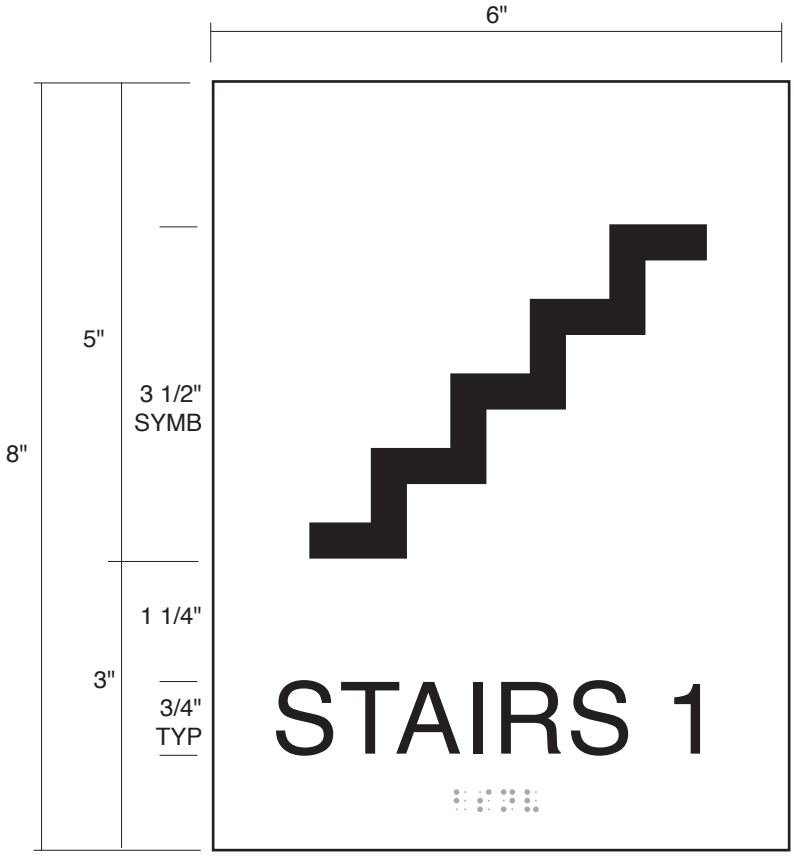
Graphic Process
Tactile cut out graphics,
Grade II Braille.

Typography
Helvetica Regular

Color
Bkgrd TBD, Subsurface
Text Color - TBD

Mounting
VHB tape.

Installation
Wall mount



SCALE: ONE HALF FULL SIZE

SignType Q1 - Directional

Sign Size
12x22”

Description
Directional Sign

Sign Messages
As scheduled.

Sign Components
1/16” Acrylic sign face, matte finish, subsurface painted. 3/16” acrylic backer sheet.
Square corners.
Vinyl text

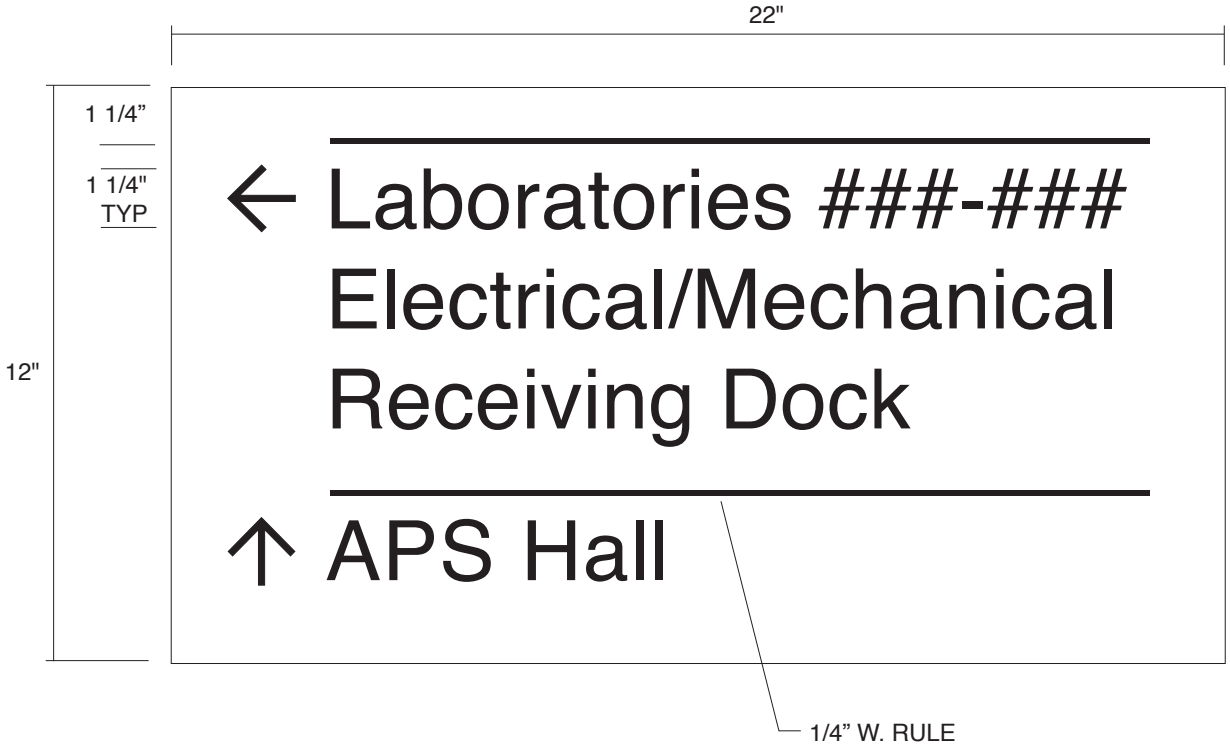
Graphic Process
Surface applied vinyl graphics

Typography
Helvetica Regular

Color
Bkgrd TBD, Subsurface
Text Color - TBD

Mounting
VHB tape.

Installation
Wall mount



SCALE: ONE QUARTER FULL SIZE

SignType R1

Sign Size
6x9”

Description
Regulatory Sign

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish,
subsurface painted.
Square corners.
Tactile graphics.

Graphic Process
Tactile cut out graphics,
Grade II Braille.

Typography
Helvetica Regular

Color
Bkgrd TBD, Subsurface
Text Color - TBD

Mounting
VHB tape.

Installation
Wall mount .

SCALE: ONE HALF FULL SIZE

SignType S1

Sign Size
5x9”

Description
Restriction Sign

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish, subsurface painted.
Square corners.

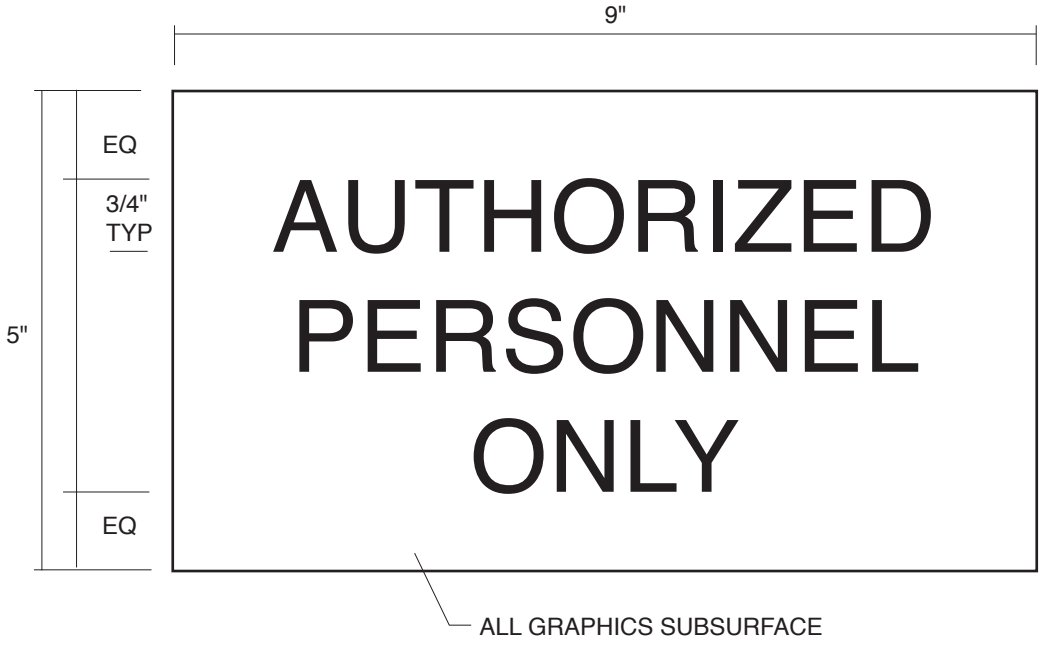
Graphic Process
Subsurface graphics

Typography
Helvetica Regular

Color
Bkgrd TBD, Subsurface
Text Color - TBD

Mounting
VHB tape.

Installation
Wall mount.



SCALE: ONE HALF FULL SIZE

SignType T - Tornado

Sign Size
9x6”

Description
Identification Sign - Restrooms

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish,
subsurface painted.
Square corners.
Tactile text

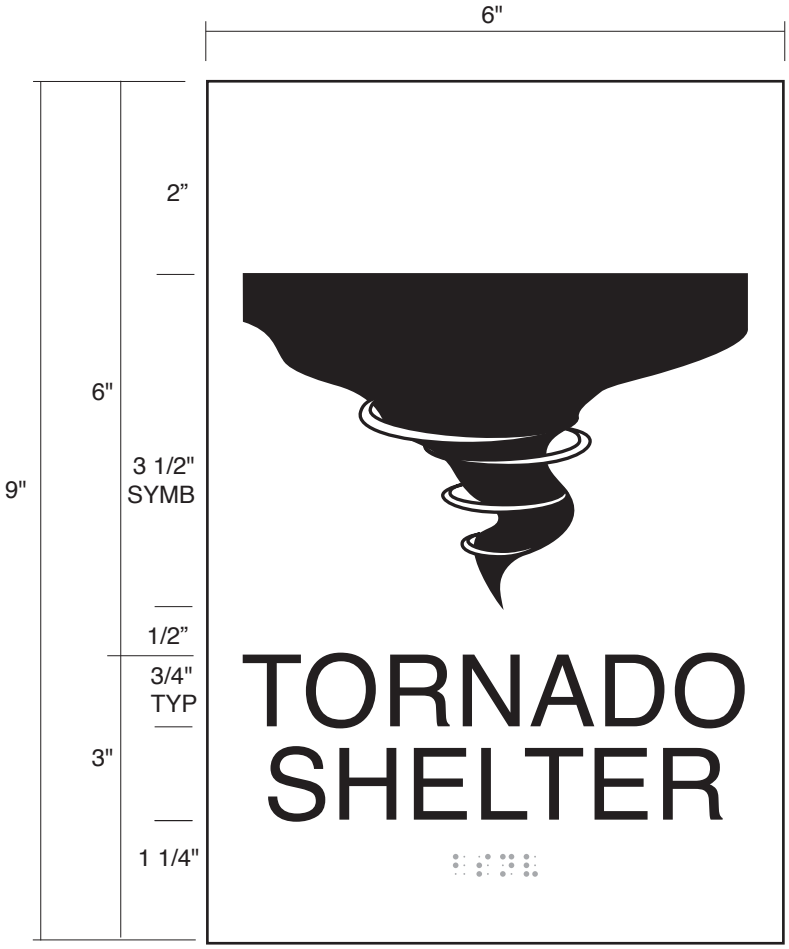
Graphic Process
Tactile cut out graphics,
Grade II Braille.

Typography
Helvetica Regular

Color
Bkgrd TBD, Subsurface
Text Color - TBD

Mounting
VHB tape.

Installation
Wall mount,
generally at restrooms,
next to Restroom ID sign



MOUNT RESTROOM & TORNADO
SIGNS NEXT TO EACH OTHER
WHERE NOTED

SCALE: ONE HALF FULL SIZE

SignType U

Sign Size
3X9”

Description
Maximum Occupancy Sign

Sign Messages
As scheduled.

Sign Components
Acrylic sign, matte finish, subsurface painted.
Square corners.

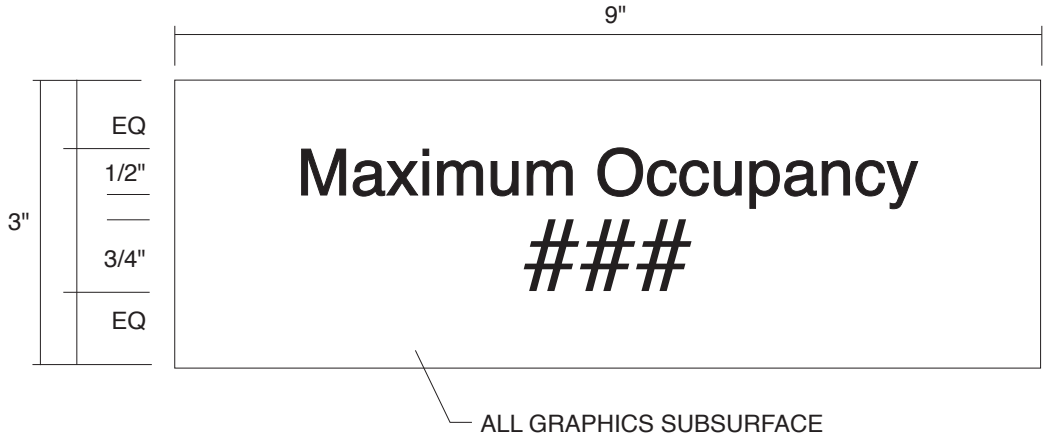
Graphic Process
Subsurface graphics

Typography
Helvetica Regular

Color
Bkgrd TBD, Subsurface
Text Color - TBD

Mounting
VHB tape.

Installation
Wall mount inside designated areas of assembly.



VERIFY MAX OCCUPANCY NUMBER FOR EACH AREA OF ASSEMBLY WHERE SUCH INFORMATION MUST BE POSTED.
DISPLAY SIGN INSIDE ROOM.

SCALE: ONE HALF FULL SIZE

SignType W1, W2 - Window Insert

Sign Size
12X9" (Vertical)
9x12" (Horizontal)

Description
Acrylic Window Sign, to display printed paper inserts

Sign Messages
NA

Sign Components
Acrylic sign, matte finish, subsurface painted border color four sides. Square corners. Clear matte window display area.

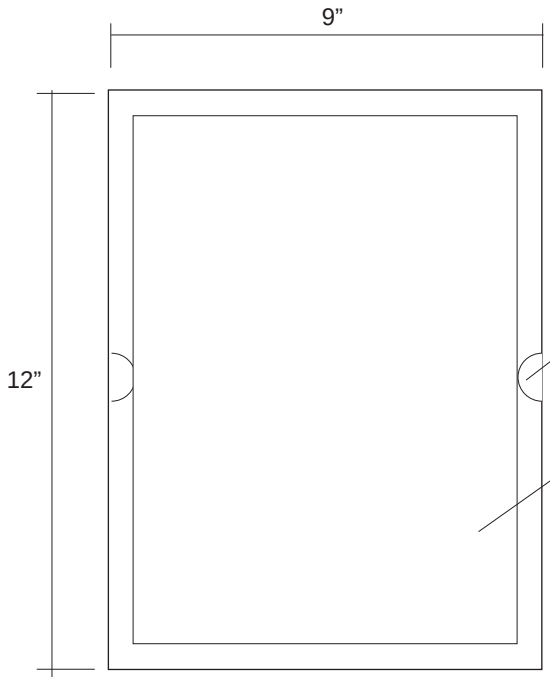
Graphic Process
NA

Typography
NA

Color
Bkgrd TBD, Subsurface
Text Color - TBD

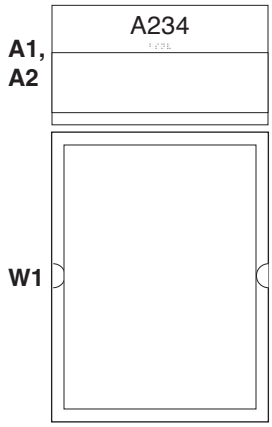
Mounting
VHB Tape

Installation
Wall mount.

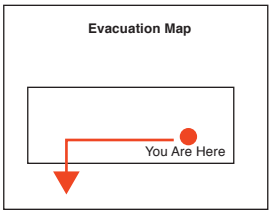


W1 - VERTICAL, 8.5X11 INSERT
(LABS, OFFICES, MISC)

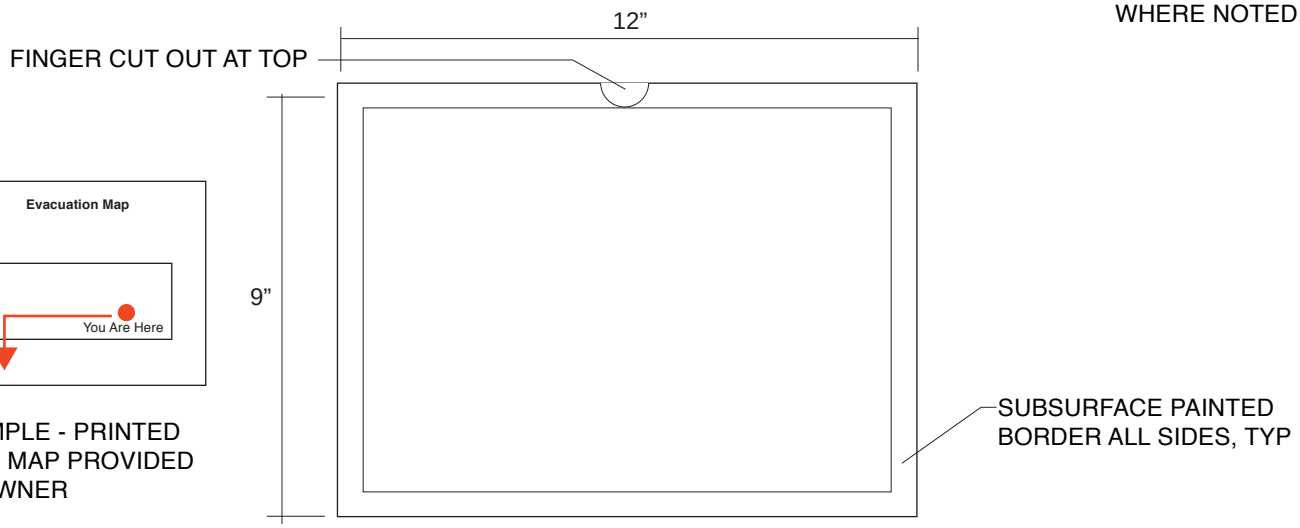
EXAMPLE - TYP
LABS WARNING
MESSAGE INSERT



COMBINE W1
DISPLAY SIGN
W/LAB ID SIGN
WHERE NOTED.



EXAMPLE - PRINTED
EVAC MAP PROVIDED
BY OWNER



W2 - HORIZONTAL, 8.5X11 INSERT
(BLDG EVAC MAPS)

SCALE: ONE HALF FULL SIZE

SignType FE

Sign Size
6x6" Each Face; 6x14" O.A.

Description
Identification Sign -
Fire Extinguishers

Sign Messages
As Shown.

Sign Components
.040 Aluminum aluminum composite sheet;
or plastic sheet, satin finish, surface painted.
Square corners.

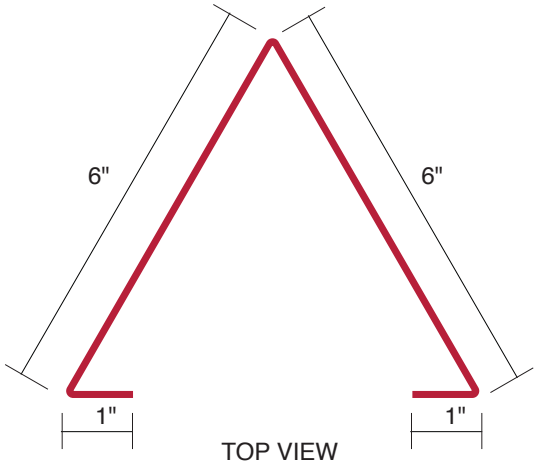
Graphic Process
Printed or applied
vinyl graphics.

Typography
Helvetica Regular

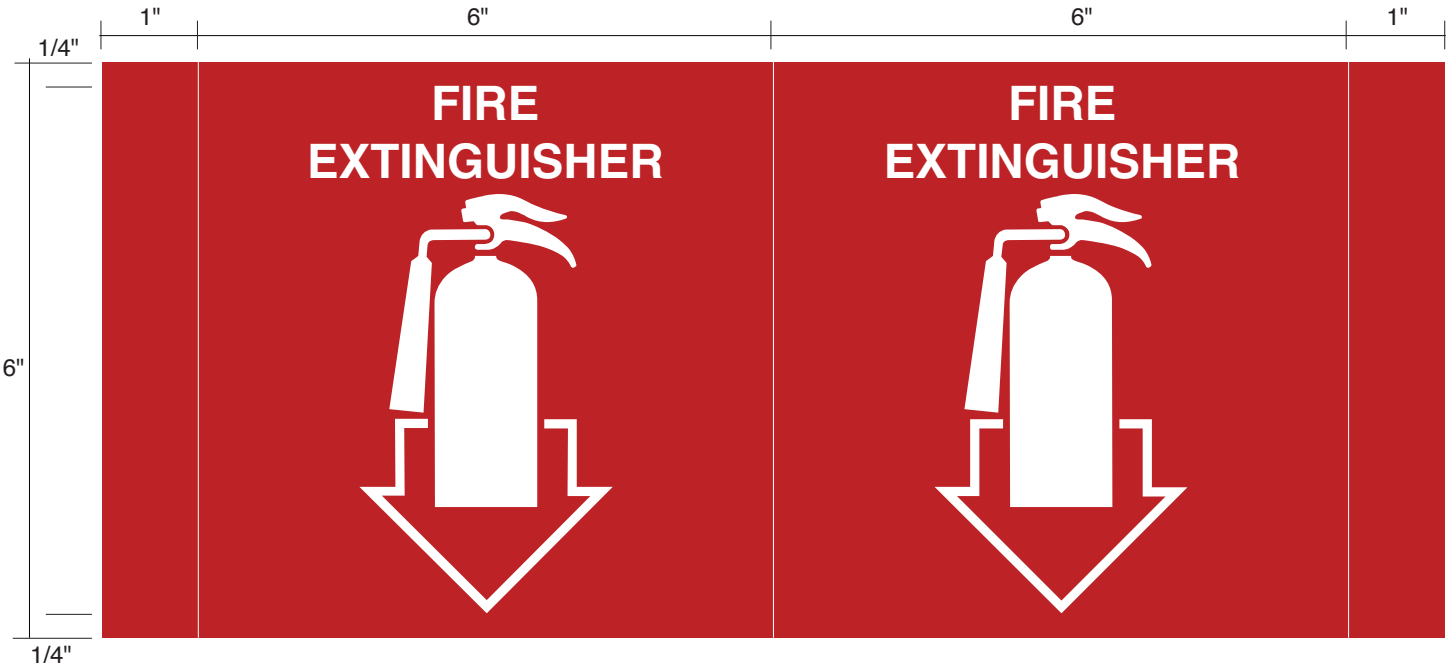
Color
Bkgrd Color - Red, Match PMS 485
Text Color - White

Mounting
Screw, keyhole.

Installation
Wall mount



TRIANGULAR SHAPE,
WALL MOUNT CENTERED
OVER FE LOCS



SCALE: ONE HALF FULL SIZE

SignType Z - Memo Clip

Sign Size
Z: 2" H. X 11/4" W

Description
Holder for display
of temporary messages.

Sign Messages
By Owner

Sign Components
Stainless steel memo clip
with steel ball bearing
friction clip

Graphic Process
NA

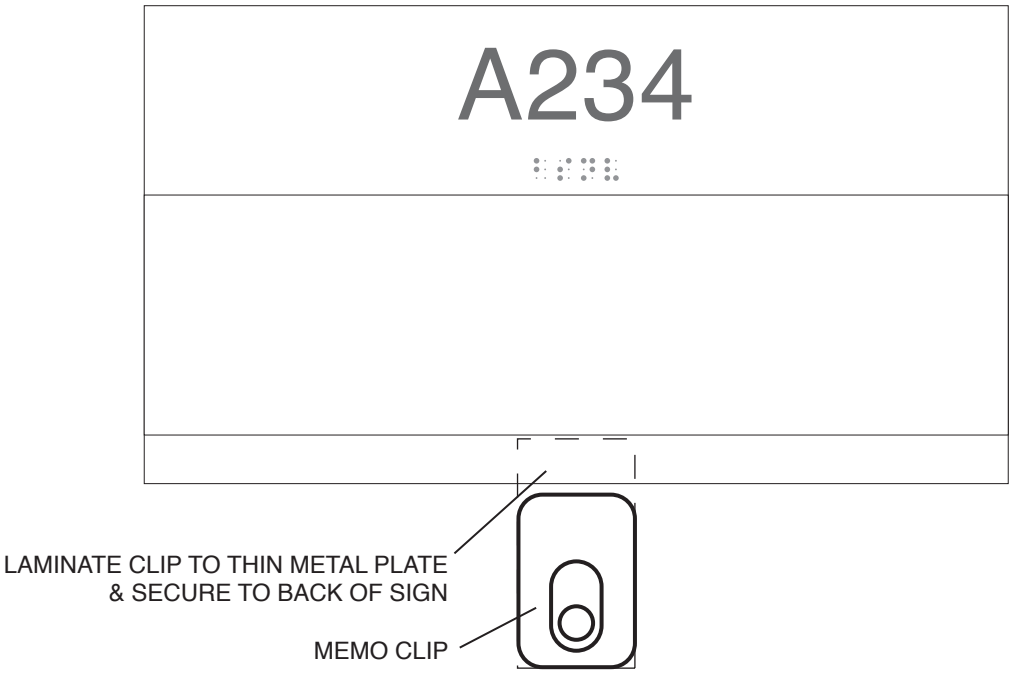
Typography
NA

Color
#4 brushed stainless
steel finish

Mounting
VHB tape/mechanically mount
to select room ID signs.

Installation
Wall mount below sign.

CLIP FOR TEMP MESSAGES
ST. STEEL MEMO CLIP #M-22
MFRD BY PRODYNE, WWW.PRODYNE.COM



Plaque Sign Types, Tactile, Glass Backup Mounting (GBU)

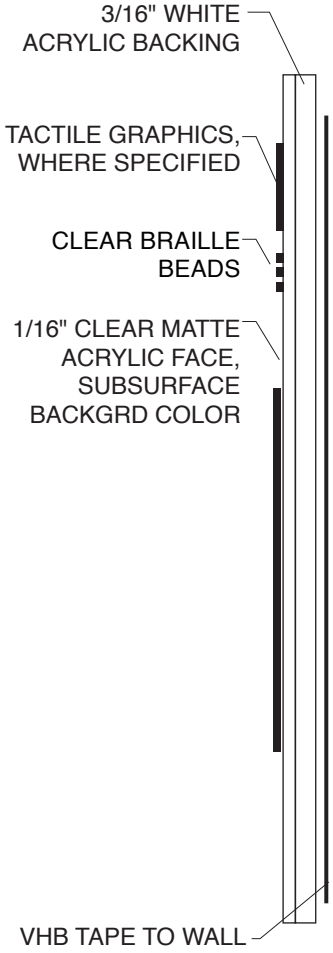
Sign Size
Varies.

Description
Plaque sign types
and Window Frame
sign types

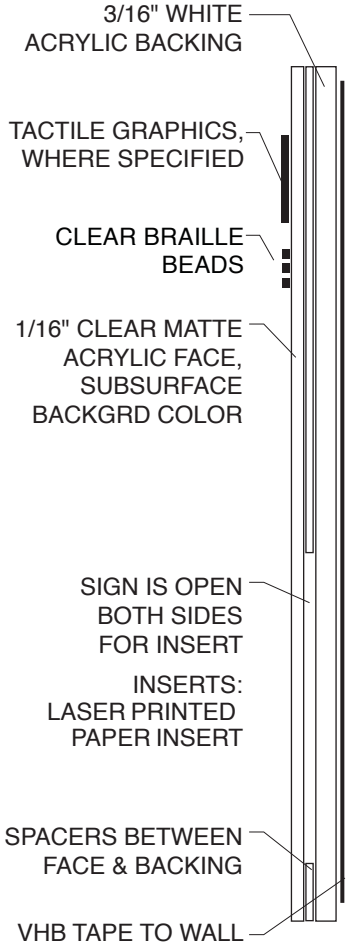
Graphic Process
As Noted

Mounting
Tape Mount

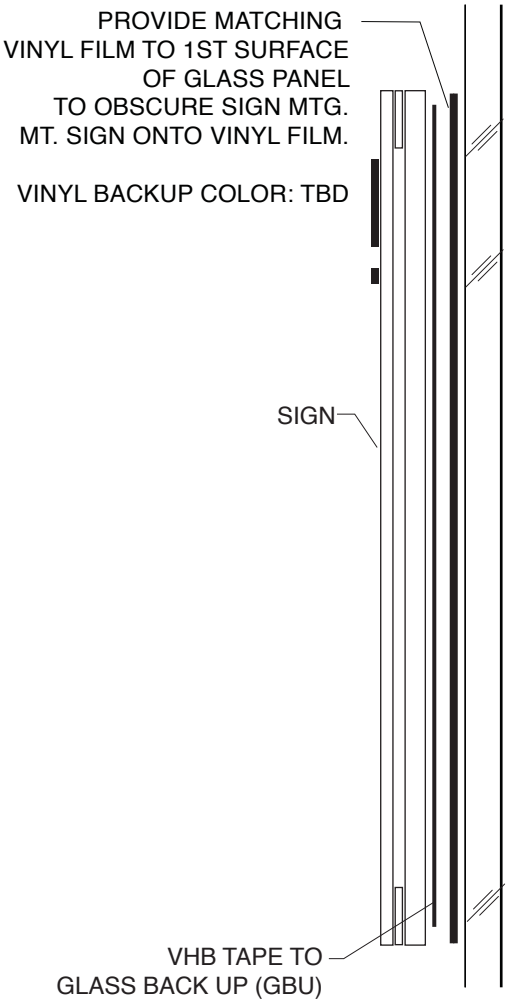
Installation
Wall Mount



PLAQUE - TYP PROFILE
TACTILE GRAPHICS



WINDOW/INSERT SIGN - TYP PROFILE
& TACTILE GRAPHICS



PROFILE - MTG ON GLASS

Plaque Sign Types, Non-Tactile

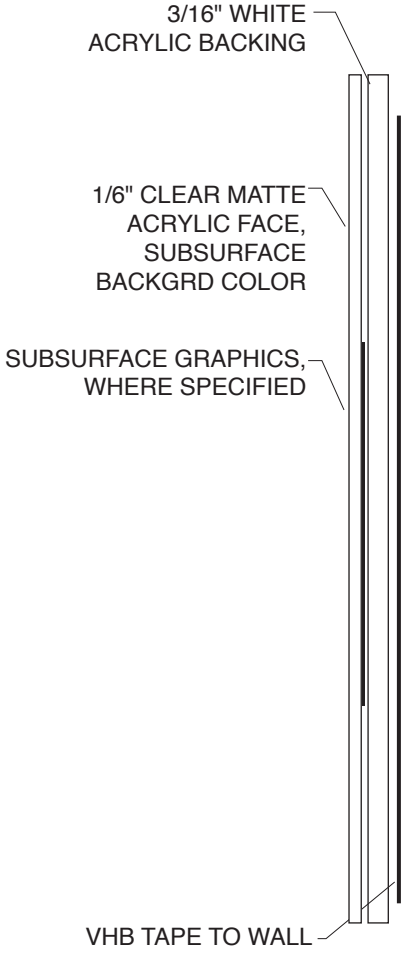
Sign Size
Varies.

Description
Plaque sign types
and Window Frame
sign types

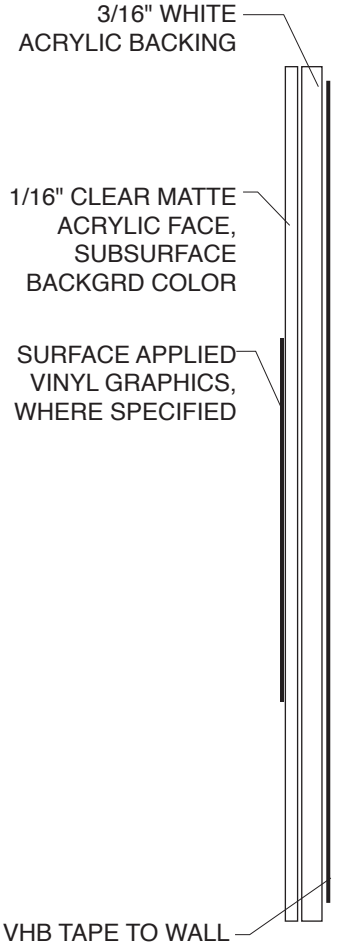
Graphic Process
As Noted

Mounting
Tape Mount

Installation
Wall Mount

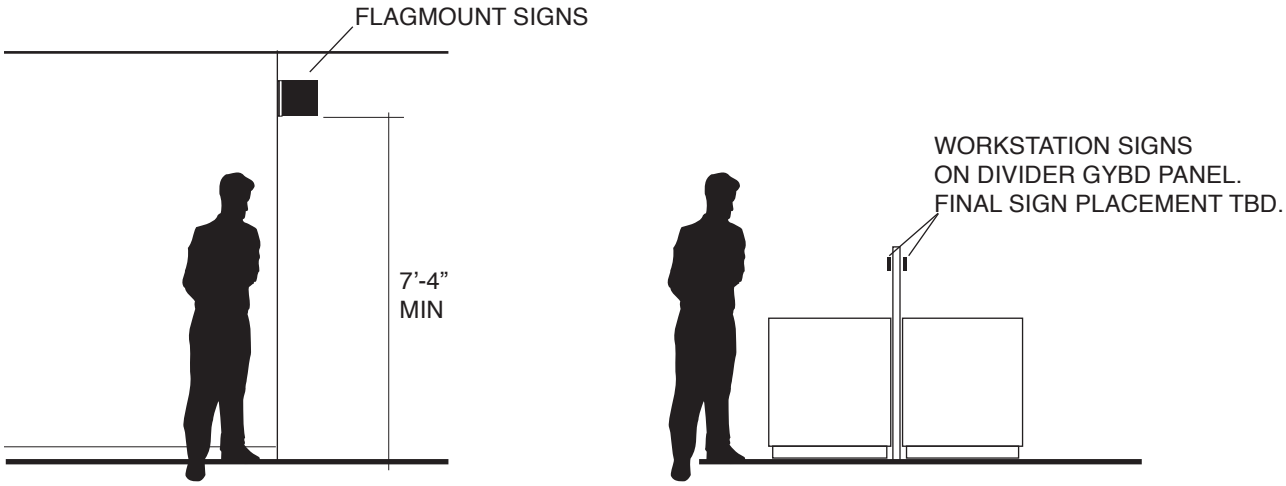


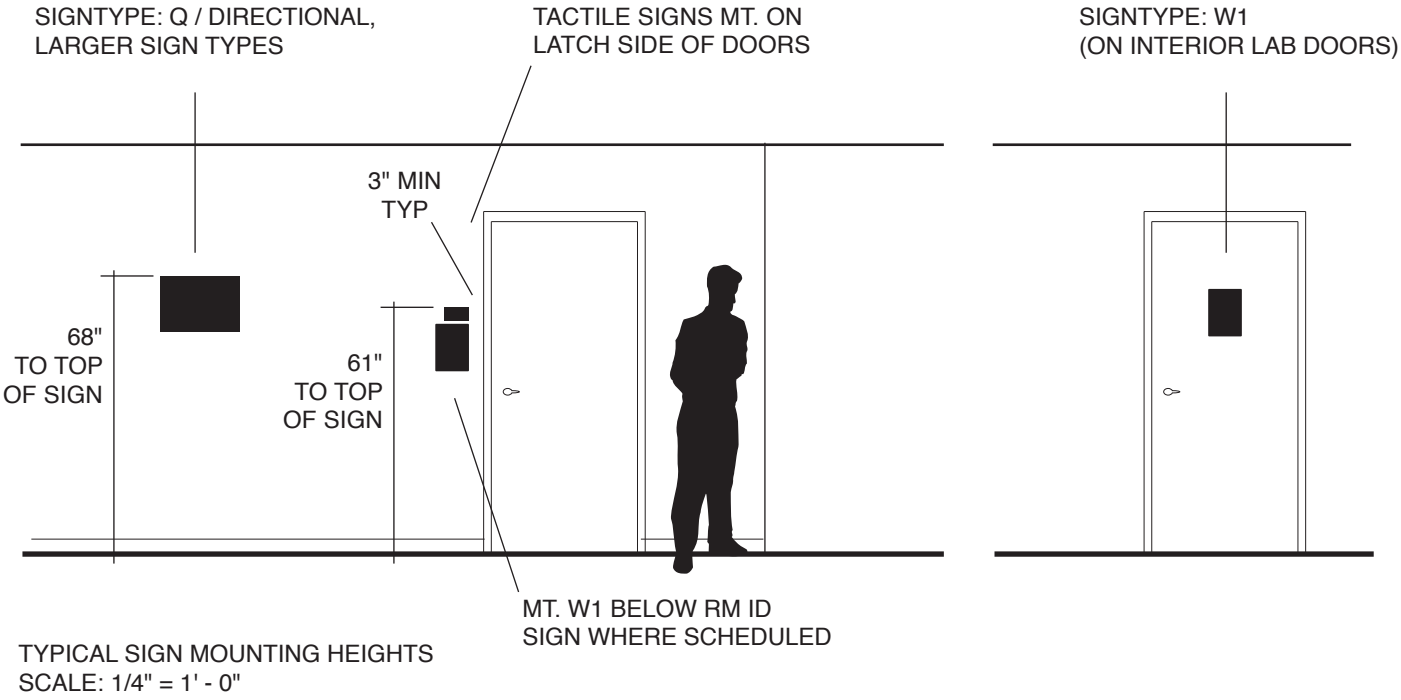
PLAQUE - TYP PROFILE
SUBSURFACE GRAPHICS



DIRECTIONAL SIGN - TYP PROFILE
VINYL GRAPHICS

Typical Sign Mounting





TYPICAL SIGN MOUNTING HEIGHTS
SCALE: 1/4" = 1' - 0"

SECTION 10 21 13

TOILET COMPARTMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Steel toilet compartments configured as toilet enclosures and urinal screens.

B. Related Sections:
1. Section 05 50 00 "Metal Fabrications" for supports that attach ceiling-hung compartments to overhead structural system.
2. Section 10 28 00 "Toilet and Bath Accessories" for toilet tissue dispensers, grab bars, and similar accessories.

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:
1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
   a. Include statement indicating cost for each product having recycled content.

C. Shop Drawings: For toilet compartments. Include plans, elevations, sections, details, and attachments to other work.
1. Show locations of cutouts for compartment-mounted toilet accessories.
2. Show locations of reinforcements for compartment-mounted grab bars.
3. Show locations of centerlines of toilet fixtures.
4. Show ceiling grid and overhead support or bracing locations.

D. Samples for Initial Selection: For each type of unit indicated. Include Samples of hardware and accessories involving material and color selection.

E. Samples for Verification: For the following products, in manufacturer's standard sizes unless otherwise indicated:
1. Each type of material, color, and finish required for units, prepared on 6-inch- square Samples of same thickness and material indicated for Work.
2. Each type of hardware and accessory.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of toilet compartment, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For toilet compartments to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Comply with requirements in GSA's CID-A-A-60003, "Partitions, Toilets, Complete."

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84, or another standard acceptable to authorities having jurisdiction, by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 450 or less.

C. Regulatory Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA) and Architectural Barriers Act (ABA) Accessibility Guidelines for Buildings and Facilities" and ICC/ANSI A117.1 for toilet compartments designated as accessible.

1.7 PROJECT CONDITIONS

A. Field Measurements: Verify actual locations of toilet fixtures, walls, columns, ceilings, and other construction contiguous with toilet compartments by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aluminum Castings: ASTM B 26/B 26M.

B. Aluminum Extrusions: ASTM B 221.

C. Steel Sheet: Commercial steel sheet for exposed applications; mill phosphatized and selected for smoothness.
1. Hot-Dip Galvanized: ASTM A 653/A 653M, either hot-dip galvanized or galvannealed.

D. Stainless-Steel Castings: ASTM A 743/A 743M.

2.2 STEEL UNITS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Accurate Partitions Corporation; or comparable product by one of the following:
1. Hadrian Manufacturing Inc.
2. Knickerbocker Partition Corporation.
3. Metpar Corp.
4. Sanymetal.
5. Weis/Robart Partitions.

B. Toilet-Enclosure Style: Floor anchored.

C. Urinal-Screen Style: Wall hung, flat panel.

D. Door, Panel, and Pilaster Construction: Seamless, metal facing sheets pressure laminated to core material; with continuous, interlocking molding strip or lapped-and-formed edge closures; corners secured by welding or clips and exposed welds ground smooth. Provide with no-sightline system. Exposed surfaces shall be free of pitting, seam marks, roller marks, stains, discolorations, telegraphing of core material, or other imperfections.
   1. Core Material: Manufacturer's standard sound-deadening honeycomb of resin-impregnated kraft paper in thickness required to provide finished thickness of 1 inch for doors and panels and 1-1/4 inches for pilasters.
   2. Grab-Bar Reinforcement: Provide concealed internal reinforcement for grab bars mounted on units.
   3. Tapping Reinforcement: Provide concealed reinforcement for tapping (threading) at locations where machine screws are used for attaching items to units.

E. Urinal-Screen Construction:
   1. Flat-Panel Urinal Screen: Matching panel construction.

F. Facing Sheets and Closures: Hot-dip galvanized-steel sheet with nominal base-metal (uncoated) thicknesses as follows:
   1. Pilasters, Braced at Both Ends: Manufacturer's standard thickness, but not less than 0.036 inch.
   2. Panels: 0.036 inch.
   3. Doors: Manufacturer's standard thickness, but not less than 0.030 inch.
   4. Flat-Panel Urinal Screens: Thickness matching the panels.

G. Pilaster Shoes: Stainless-steel sheet, not less than 0.031-inch nominal thickness and 3 inches high, finished to match hardware.

H. Brackets (Fittings):
   1. Stirrup Type: Ear or U-brackets; clear-anodized aluminum .
   2. Full-Height (Continuous) Type: Manufacturer's standard design; aluminum.

I. Steel-Sheet Finish: Immediately after cleaning and pretreating, apply manufacturer's standard baked-on finish, including thermosetting, electrostatically applied, and powder coatings. Comply with coating manufacturer's written instructions for applying and baking. Apply one color in each room.
   1. Color: Accurate; Light Gray 990.

2.3 ACCESSORIES

A. Hardware and Accessories: Manufacturer's standard design, heavy-duty operating hardware and accessories.
   1. Material: Stainless steel.
   2. Hinges: Manufacturer's standard continuous, spring-loaded type.
   3. Latch and Keeper: Manufacturer's standard surface-mounted latch unit designed for emergency access and with combination rubber-faced door strike and keeper. Provide units that comply with regulatory requirements for accessibility at compartments designated as accessible.
   4. Clothes Hook and Bumper:
      a. Basis of Design: Bobrick B-212
      b. Combination hook and rubber-tipped bumper, sized to prevent in-swinging door from hitting compartment-mounted accessories.
   5. Door Pull: Manufacturer's standard unit at out-swinging doors that complies with regulatory requirements for accessibility. Provide units on both sides of doors at compartments designated as accessible.

B. Overhead Bracing: Manufacturer's standard continuous, extruded-aluminum head rail with antigrip profile and in manufacturer's standard finish.

C. Anchorages and Fasteners: Manufacturer's standard exposed fasteners of stainless steel or chrome-plated steel or brass, finished to match the items they are securing, with theft-resistant-type heads. Provide sex-type bolts for through-bolt applications. For concealed anchors, use stainless steel, hot-dip galvanized steel, or other rust-resistant, protective-coated steel.

2.4 FABRICATION

A. Overhead-Braced Units: Provide manufacturer's standard corrosion-resistant supports, leveling mechanism, and anchors at pilasters to suit floor conditions. Provide shoes at pilasters to conceal supports and leveling mechanism.

B. Door Size and Swings: Unless otherwise indicated, provide 24-inch- wide, in-swinging doors for standard toilet compartments and 36-inch- wide, out-swinging doors with a minimum 32-inch- wide, clear opening for compartments designated as accessible.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Comply with manufacturer's written installation instructions. Install units rigid, straight, level, and plumb. Secure units in position with manufacturer's recommended anchoring devices.
   1. Maximum Clearances:
      a. Pilasters and Panels: 1/2 inch.
      b. Panels and Walls: 1 inch.

B. Overhead-Braced Units: Secure pilasters to floor and level, plumb, and tighten. Set pilasters with anchors penetrating not less than 1-3/4 inches into structural floor unless otherwise indicated in manufacturer's written instructions. Secure continuous head rail to each pilaster with no fewer than two fasteners. Hang doors to align tops of doors with tops of panels, and adjust so tops of doors are parallel with overhead brace when doors are in closed position.

C. Urinal Screens: Attach with anchoring devices to suit supporting structure. Set units level and plumb, rigid, and secured to resist lateral impact.

3.2 ADJUSTING

A. Hardware Adjustment: Adjust and lubricate hardware according to hardware manufacturer's written instructions for proper operation. Set hinges on in-swinging doors to hold doors open approximately 30 degrees from closed position when unlatched. Set hinges on out-swinging doors to return doors to fully closed position.

END OF SECTION

SECTION 10 22 26

OPERABLE PARTITIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Electronically operated, acoustical panel partitions.

B. Related Sections:
1. Section 05 50 00 "Metal Fabrications" for supports that attach supporting tracks to overhead structural system.
2. Section 09 29 00 "Gypsum Board" for fire-rated assemblies and sound barrier construction above the ceiling at track.

1.3 DEFINITIONS

A. ADA-ABA Accessibility Guidelines: U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA) and Architectural Barriers Act (ABA) Accessibility Guidelines for Buildings and Facilities."

B. STC: Sound Transmission Class.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design operable panel partitions, including comprehensive engineering analysis by a qualified structural engineer, using performance requirements and design criteria indicated.

B. Acoustical Performance: Provide operable panel partitions tested by a qualified testing agency for the following acoustical properties according to test methods indicated:
1. Noise-Reduction Requirements: Operable panel partition assembly, identical to partition tested for STC, tested for sound-absorption performance according to ASTM C 423, and rated for not less than the NRC indicated.

1.5 ACTION SUBMITTALS

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

B. LEED Submittals:
1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
   a. Include statement indicating cost for each product having recycled content.

2. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
3. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
4. Product Data for Credit IEQ 4.4: For adhesives and composite wood products, documentation indicating that products contain no urea formaldehyde.

C. Shop Drawings: Include plans, elevations, sections, details, numbered panel installation sequence, and attachments to other work.
1. For installed products indicated to comply with design loads, include structural analysis data for attachments, signed and sealed by the qualified structural engineer responsible for their preparation.
2. Indicate storage and operating clearances. Indicate location and installation requirements for hardware and track, blocking, and direction of travel.

D. Samples for Initial Selection: For each type of exposed material, finish, covering, or facing indicated.
1. Include similar Samples of accessories involving color selection.

E. Samples for Verification: For each type of exposed material, finish, covering, or facing indicated, prepared on Samples of size indicated below:
1. Textile: Full width by not less than 36-inch- long section of fabric from dye lot to be used for the Work, with specified treatments applied. Show complete pattern repeat.
2. Panel Facing Material: Manufacturer's standard-size unit, not less than 3 inches square.
3. Panel Edge Material: Not less than 3 inches long.
4. Hardware: Manufacturer's standard exposed door-operating device.

F. Delegated-Design Submittal: For operable panel partitions indicated to comply with performance requirements, including analysis data and calculations signed and sealed by the qualified structural engineer responsible for their preparation.
1. Design Calculations: Calculate requirements for seismic restraints.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Suspended ceiling components.
2. Structural members to which suspension systems will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Items penetrating finished ceiling, including the following:
   a. Lighting fixtures.
   b. HVAC ductwork, outlets, and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Smoke detectors.
   f. Access panels.
5. Plenum fire, smoke, and acoustical barriers.

B. Setting Drawings: For embedded items and cutouts required in other work, including support-beam, mounting-hole template.

C. Qualification Data: For qualified Installer and testing agency.

D. Seismic Qualification Certificates: For operable panel partitions, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Product Certificates: For each type of operable panel partition, from manufacturer.

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

G. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For operable panel partitions to include in maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   1. Panel finish facings and finishes for exposed trim and accessories. Include precautions for cleaning materials and methods that could be detrimental to finishes and performance.
   2. Seals, hardware, track, carriers, and other operating components.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials from the same production run that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Panel Finish-Facing Material: Furnish full width in quantity to cover both sides of two panels when installed.

1.9 QUALITY ASSURANCE

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

B. Fire-Test-Response Characteristics: Provide panels with finishes meeting one of the following as determined by testing identical products by UL or another testing and inspecting agency acceptable to authorities having jurisdiction:
   1. Surface-Burning Characteristics: As determined by testing per ASTM E 84.
      a. Flame-Spread Index: 25 or less.
      b. Smoke-Developed Index: 450 or less.
   2. Fire Growth Contribution: Meeting acceptance criteria of local code and authorities having jurisdiction when tested according to NFPA 265.

C. Preinstallation Conference: Conduct conference at Project site.

1.10 PROJECT CONDITIONS

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

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace

components of operable panel partitions that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Faulty operation of operable panel partitions.
   b. Deterioration of metals, metal finishes, and other materials beyond normal wear.
2. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel Frame: Steel sheet, manufacturer's standard nominal minimum thickness for uncoated steel.

B. Steel Face/Liner Sheets: Tension-leveled steel sheet, manufacturer's standard nominal minimum thickness for uncoated steel.

C. Medium-Density Fiberboard: ANSI A208.2, made with binder containing no urea formaldehyde.

D. Adhesives: Manufacturer's standard products that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.2 OPERABLE ACOUSTICAL PANELS

A. Operable Acoustical Panels: Operable acoustical panel partition system, including panels, seals, finish facing, suspension system, operators, and accessories.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Acoustiseal 933E series by Modernfold, Inc., a DORMA Group Company; or comparable product by one of the following:
      a. Hufcor.
      b. Panelfold Inc.

B. Panel Operation: Electronically operated, continuously hinged partitions.

C. Panel Construction: Provide top reinforcement as required to support panel from suspension components and provide reinforcement for hardware attachment. Fabricate panels with tight hairline joints and concealed fasteners. Fabricate panels so finished in-place partition is rigid; level; plumb; aligned, with tight joints and uniform appearance; and free of bow, warp, twist, deformation, and surface and finish irregularities.

D. Dimensions: Fabricate operable acoustical panel partitions to form an assembled system of dimensions indicated and verified by field measurements.
   1. Panel Width: Standard widths.

E. STC: Not less than 50

F. Panel Weight: 8 lb/sq. ft. maximum.

G. Panel Thickness: nominal 3.06 inches

H. Panel Closure: Manufacturer's standard.
   1. Initial Closure: Flexible, resilient PVC, bulb-shaped acoustical seal .
   2. Final Closure: Flexible, resilient PVC, bulb-shaped acoustical seal.

I. Hardware: Manufacturer's standard as required to operate operable panel partition and accessories; with decorative, protective finish.
   1. Hinges: Manufacturer's standard.
   2. Exit Device: Manufacturer's standard.

2.3 SEALS

A. General: Provide types of seals indicated that produce operable panel partitions complying with acoustical performance requirements and the following:
   1. Manufacturer's standard seals.
   2. Seals made from materials and in profiles that minimize sound leakage.
   3. Seals fitting tight at contact surfaces and sealing continuously between adjacent panels and between operable panel partition perimeter and adjacent surfaces, when operable panel partition is extended and closed.

B. Vertical Interlocking Sound Seals between panels: Roll-formed astragals, with reversible tongue and groove configuration in each panel edge, for universal panel operation. Rigid plastic astragals or astragals in only one panel edge are not acceptable.

C. Horizontal Top Seals: Continuous contact extruded vinyl bulb shape with pairs of non-contacting vinyl fingers to prevent distortion without the need for mechanically operated parts.

D. Horizontal Bottom Seals: PVC-faced, mechanical, retractable, constant-force-contact seal exerting uniform constant pressure on floor when extended, ensuring horizontal and vertical sealing and resisting panel movement.
   1. Automatically Operated for Acoustical Panels: Modernfold IA2 bottom seal. Automatic operable seals providing nominal 2-inch operating clearance with an operating range of +1/2-inch to 1-1/2 inch which automatically drop as panels are positioned, without the need for tools or cranks.

2.4 FINISH FACING

A. General: Provide finish facings for panels that comply with indicated fire-test-response characteristics and that are factory applied to operable panel partitions with appropriate backing, using mildew-resistant nonstaining adhesive as recommended by facing manufacturer's written instructions.

B. Facing Materials: Porcelain enamel markerboard surfaces as described in Article 2.7.C.

C. Hinges: Smoke Gray to match trim

D. Cap-Trimmed Edges: Protective perimeter-edge trim with tight hairline joints concealing edges of panel and finish facing, finished as follows:
   1. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper required to comply with performance requirements; and with manufacturer's standard clear anodic finish.

2.5 SUSPENSION SYSTEMS

A. Suspension Tracks: Steel or aluminum mounted directly to overhead structural support, designed for type of operation, size, and weight of operable panel partition indicated. Size track to support partition operation and storage without damage to suspension system, operable panel partitions, or adjacent construction. Limit track deflection to no more than 0.10 inch between bracket supports. Provide a continuous system of track sections and accessories to accommodate configuration and layout indicated for partition operation and storage.

1. Suspension system (Basis of design): Modernfold #30
   a. Suspension Tracks: Track shall be structural aluminum. Static loading of track with brackets at 48-inch (1220 mm) centers shall show no failure of track or brackets at 5,000 pounds (2250 kg) point loading at mid-span. Track shall be supported by adjustable steel hanger brackets connected to structural support by pairs of 3/8-inch (9.5 mm) diameter threaded rods.
   b. Exposed track soffit: Track soffit to be integral to track shape and shall be powder-coated off white paint finish. Track must accommodate termination of plenum sound barriers on both sides of track for maximum sound control.
2. Carriers: One trolley in alternating panels with 3-inch (76.2 mm) diameter glass reinforced nylon, all steel precision-ground ball-bearing wheels. Steel wheeled or reinforced polymer

2.6 ELECTRIC OPERATORS

A. General: Provide factory-assembled electric operation system of size and capacity recommended and provided by operable panel partition manufacturer for partition specified; with electric motor and factory-prewired motor controls, speed reducer, chain drive, remote-control stations, control devices, and accessories required for proper operation. Include wiring from motor control to motor. Coordinate operator wiring requirements and electrical characteristics with building electrical system.

B. Comply with NFPA 70.
   1. 208V, single phase

C. Control Equipment: Complying with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6.

D. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1.

E. Remote-Control Stations: Two single-key-operated, constant-pressure control stations located remotely from each other on opposite sides and opposite ends of partition run. Wire in series to require simultaneous activation of both key stations to operate partition. Each three-position control station labeled "Open," "Close," and " Stop." Provide two keys per station.

F. Obstruction-Detection Devices: Provide each motorized operable panel partition with automatic safety sensor indicated, that causes operator to immediately shut off motor.
   1. Sensor Edge: Contact-pressure-sensitive safety edge along partition's leading edge.
   2. Sensor Mat: Electrically operated, contact-weight-sensitive safety mat in storage pocket area.
   3. Infrared Sensor System: Designed to detect an obstruction in partition's path and sound an audible alarm, without obstruction contacting partition.

G. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop operable panel partition at fully extended and fully stacked positions.

H. Emergency Release Mechanism: Quick disconnect-release of electric-motor drive system, permitting manual operation in event of operating failure.

2.7 ACCESSORIES

A. Storage Pocket Door: To match adjacent wood door panels.

B. Electric Interlock: Provide each motorized operable panel partition with electric interlocks at locations indicated, to prevent operation of operable panel partition under the following conditions:
1. On storage pocket door, to prevent operation if door is not in fully open position.
2. On partitions at location of convergence by another partition, to prevent operation if merging partitions are in place.

C. Work Surfaces: Quantities, placement, and size indicated.
1. Surface: Porcelain steel marker/projection surface.
2. Surface Color: As selected by Architect from manufacturer's full range.
3. Size: Full width and height of panel.
4. Trim: Aluminum slip-on or snap-on trim with no visible screws or exposed joints and with corners mitered to a neat, hairline joint.

D. Chalk Tray and Eraser Pocket: Manufacturer's standard.
1. Aluminum with Smoke Gray color anodic finish.

EXECUTION

2.8 EXAMINATION

A. Examine flooring, structural support, and opening, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of operable panel partitions.

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

2.9 INSTALLATION

A. General: Comply with ASTM E 557 except as otherwise required by operable panel partition manufacturer's written installation instructions.

B. Install operable panel partitions and accessories after other finishing operations, including painting, have been completed.

C. Broken, cracked, chipped, deformed, or unmatched panels are not acceptable.

D. Broken, cracked, deformed, or unmatched gasketing or gasketing with gaps at butted ends is not acceptable.

2.10 ADJUSTING

A. Adjust operable panel partitions to operate smoothly, without warping or binding. Lubricate hardware and other moving parts.

B. Adjust to operate smoothly and easily, without binding or warping. Check and readjust operating hardware. Confirm that latches and locks engage accurately and securely without forcing or binding.

2.11 FIELD QUALITY CONTROL

A. Light-Leakage Test: Illuminate one side of partition installation and observe vertical joints and top and bottom seals for voids; adjust partitions for acceptable fit.

B. NIC Testing: Owner will engage a qualified testing agency to perform tests and inspections.

C. Testing Methodology: Perform testing of installed operable panel partition for noise isolation according to ASTM E 336, determined by ASTM E 413, and rated for not less than NIC indicated. Adjust and fit partitions to comply with NIC test method requirements.

D. Testing Extent: Testing agency shall randomly select one operable panel partition installation(s) for testing.

E. Repair or replace operable panel partitions that do not comply with requirements.

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

G. Prepare test and inspection reports.

2.12 CLEANING

A. Clean soiled surfaces of operable panel partitions to remove dust, loose fibers, fingerprints, adhesives, and other foreign materials according to manufacturer's written instructions.

2.13 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain operable panel partitions.

END OF SECTION

SECTION 10 26 00

WALL AND DOOR PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Corner guards.

B. Related Sections:
   1. Section 08 71 00 "Door Hardware" for metal kick, mop, and push plates.

1.3 ACTION SUBMITTALS

A. Product Data: Include construction details, material descriptions, impact strength, dimensions of individual components and profiles, and finishes for each impact-resistant corner protection unit.

B. LEED Submittals:
   1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
      a. Include statement indicating cost for each product having recycled content.
   2. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

C. Shop Drawings: For each impact-resistant corner protection unit showing locations and extent. Include sections, details, and attachments to other work.

D. Samples for Initial Selection: For each type of impact-resistant wall protection unit indicated.

E. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below.
   1. Corner Guards: 12 inches long. Include examples of joinery, corners, and field splices.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Certificates: For each impact-resistant plastic material, from manufacturer.

C. Material Test Reports: For each impact-resistant plastic material.

D. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each impact-resistant wall protection unit to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Corner-Guard Covers: Full-size metal covers of maximum length equal to 2 percent of each type, color, and texture of units installed, but no fewer than two, 4-foot- long units.

B. Include mounting and accessory components. Replacement materials shall be from same production run as installed units.

1.7 QUALITY ASSURANCE

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

B. Source Limitations: Obtain impact-resistant wall protection units from single source from single manufacturer.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of impact-resistant wall protection units and are based on the specific system indicated. Refer to Section 014000 "Quality Requirements."

D. Revise subparagraph below to suit Project.
   1. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.

E. Surface-Burning Characteristics: Provide impact-resistant, plastic wall protection units with surface-burning characteristics as determined by testing identical products per ASTM E 84, NFPA 255, or UL 723 by UL or another qualified testing agency.

F. Regulatory Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and ICC/ANSI A117.1.

G. Preinstallation Conference: Conduct conference at Project site.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store corner protection units in original undamaged packages and containers inside well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.
   1. Store corner-guard covers in a vertical position.

1.9 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install impact-resistant wall protection units until building is enclosed and weatherproof, wet work is complete and dry, and HVAC system is operating and maintaining temperature at 70 deg F for not less than 72 hours before beginning installation and for the remainder of the construction period.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of impact-resistant wall protection units that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures.
      b. Deterioration of materials beyond normal use.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Stainless-Steel Sheet: ASTM A 240/A 240M.

B. Fasteners: Aluminum, nonmagnetic stainless-steel, or other noncorrosive metal screws, bolts, and other fasteners compatible with items being fastened. Use security-type fasteners where exposed to view.

2.2 CORNER GUARDS

A. Surface-Mounted, Metal Corner Guards: Fabricated from one-piece, formed or extruded metal with formed edges; with 90- or 135-degree turn to match wall condition.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide or comparable product by one of the following:
      a. Construction Specialties, Inc.
      b. IPC Door and Wall Protection Systems; Division of InPro Corporation.
      c. Korogard Wall Protection Systems; a division of RJF International Corporation.
   2. Material: Stainless steel, Type 304.
      a. Thickness: Minimum 0.0625 inch.
      b. Finish: Directional satin, No. 4.
   3. Wing Size: Nominal 2-1/2 by 2-1/2 inches.
   4. Corner Radius: 3/4 inch.
   5. Mounting: Oval head, countersunk screws through factory-drilled mounting holes.

2.3 FABRICATION

A. Fabricate impact-resistant wall protection units to comply with requirements indicated for design, dimensions, and member sizes, including thicknesses of components.

B. Assemble components in factory to greatest extent possible to minimize field assembly. Disassemble only as necessary for shipping and handling.

C. Fabricate components with tight seams and joints with exposed edges rolled. Provide surfaces free of wrinkles, chips, dents, uneven coloration, and other imperfections. Fabricate members and fittings to produce flush, smooth, and rigid hairline joints.

2.4 METAL FINISHES

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Remove tool and die marks and stretch lines, or blend into finish.
   2. Grind and polish surfaces to produce uniform finish, free of cross scratches.
   3. Run grain of directional finishes with long dimension of each piece.

4. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

B. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine walls to which impact-resistant wall protection will be attached for blocking, grounds, and other solid backing that have been installed in the locations required for secure attachment of support fasteners.
   1. For impact-resistant wall protection units attached with adhesive or foam tape, verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.

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

3.2 PREPARATION

A. Complete finishing operations, including painting, before installing impact-resistant wall protection system components.

B. Before installation, clean substrate to remove dust, debris, and loose particles.

3.3 INSTALLATION

A. General: Install impact-resistant wall protection units level, plumb, and true to line without distortions. Do not use materials with defects that might be visible in the finished Work.
   1. Install impact-resistant wall protection units in locations and at mounting heights indicated on Drawings or, if not indicated, at heights indicated below:
   2. Provide splices, mounting hardware, anchors, and other accessories required for a complete installation.
      a. Provide anchoring devices to withstand imposed loads.
      b. Where splices occur in horizontal runs of more than 20 feet, splice aluminum retainers and plastic covers at different locations along the run, but no closer than 12 inches.
      c. Adjust end and top caps as required to ensure tight seams.

3.4 CLEANING

A. Remove excess adhesive using methods and materials recommended in writing by manufacturer.

END OF SECTION

SECTION 10 28 00

TOILET AND BATH ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Public-use washroom accessories.
      a. Coffee bar
   2. Public-use shower room accessories.
   3. Underlavatory guards.
   4. Custodial accessories.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include the following:
   1. Construction details and dimensions.
   2. Anchoring and mounting requirements, including requirements for cutouts in other work and substrate preparation.
   3. Material and finish descriptions.
   4. Features that will be included for Project.
   5. Manufacturer's warranty.

B. Samples: Full size, for each accessory item to verify design, operation, and finish requirements.
   1. Approved full-size Samples will be returned and may be used in the Work.

C. Product Schedule: Indicating types, quantities, sizes, and installation locations by room of each accessory required.
   1. Identify locations using room designations indicated.
   2. Identify products using designations indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For toilet and bath accessories to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Source Limitations: For products listed together in the same Part 2 articles, obtain products from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.7 COORDINATION

A. Coordinate accessory locations with other work to prevent interference with clearances required for access by people with disabilities, and for proper installation, adjustment, operation, cleaning, and servicing of accessories.

B. Deliver inserts and anchoring devices set into concrete or masonry as required to prevent delaying the Work.

1.8 WARRANTY

A. Special Mirror Warranty: Manufacturer's standard form in which manufacturer agrees to replace mirrors that develop visible silver spoilage defects and that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Stainless Steel: ASTM A 666, Type 304, 0.031-inch (0.8-mm) minimum nominal thickness unless otherwise indicated.

B. Steel Sheet: ASTM A 1008/A 1008M, Designation CS (cold rolled, commercial steel), 0.036-inch (0.9-mm) minimum nominal thickness.

C. Galvanized-Steel Mounting Devices: ASTM A 153/A 153M, hot-dip galvanized after fabrication.

D. Fasteners: Screws, bolts, and other devices of same material as accessory unit and tamper-and-theft resistant where exposed, and of galvanized steel where concealed.

E. Mirrors: ASTM C 1503, Mirror Glazing Quality, clear-glass mirrors, nominal 6.0 mm thick.

2.2 PUBLIC-USE WASHROOM ACCESSORIES
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Bobrick Washroom Equipment, Inc. product indicated on Drawings or comparable product by one of the following:
   2. A & J Washroom Accessories, Inc.
   3. American Specialties, Inc.
   4. Bradley Corporation.
   5. GAMCO Specialty Accessories; a division of Bobrick Washroom Equipment, Inc.
   6. Tubular Specialties Manufacturing, Inc.

B. Toilet Tissue (Roll) Dispenser:
   1. Basis-of-Design Product: Bobrick B2888 Classic series.
   2. Description: multi-roll toilet tissue dispenser.
   3. Mounting: Surface mounted.
   4. Material and Finish: Stainless steel, No. 4 finish (satin).

C. Paper Towel Dispenser/Waste Receptacle:
   1. Basis-of-Design Product: Bobrick B3944, Classic series.
   2. Description: recessed convertible paper towel and waste receptacle
   3. Mounting: recess mounted.
   4. Material and Finish: Stainless steel, No. 4 finish (satin).
   5. Lockset: Tumbler type.

D. Paper Towel Dispenser (Coffee Bar):
   1. Basis-of-Design Product: Bobrick B2620, Classic series.
   2. Mounting: surface mounted.

E. Liquid-Soap Dispenser (Group Occupancy Toilet Rooms):
   1. Basis-of-Design Product: Bradley #6315-KT0000.
   2. Description: Lavatory mounted soap dispenser, bottle of soap and batteries.

F. Liquid-Soap Dispenser (Single Occupancy Toilet Rooms):
   1. Basis-of-Design Product: Bobrick; B-2111 Classic Series.
   2. Description: Surface mounted soap dispenser, bottle of soap and batteries.

G. Grab Bar:
   1. Basis-of-Design Product: Bobrick Classic series.
   2. Mounting: Flanges with concealed fasteners.
   3. Material: Stainless steel, 0.05 inch (1.3 mm) thick.
      a. Finish: Smooth, No. 4 finish (satin) on ends and slip-resistant texture in grip area.
   4. Outside Diameter: 1-1/4 inches (32 mm).
   5. Configuration and Length: As indicated on Drawings.

H. Dispenser:
   1. Basis-of-Design Product: Bobrick B282.
   2. Type: Sanitary napkin and tampon.
   3. Mounting: Surface mounted.
   4. Operation: No coin (free).
   5. Exposed Material and Finish: Stainless steel, No. 4 finish (satin).
   6. Lockset: Tumbler type with separate lock and key for coin box.

I. Sanitary-Napkin Disposal Unit:
   1. Mounting: Surface mounted.
   2. Door or Cover: Self-closing, disposal-opening cover.
   3. Receptacle: Removable.
   4. Material and Finish: Stainless steel, No. 4 finish (satin).

J. Seat-Cover Dispenser:
   1. Basis-of-Design Product: Bobrick B221.
   2. Mounting: Surface mounted.
   3. Exposed Material and Finish: Stainless steel, No. 4 finish (satin).
   4. Lockset: Tumbler type.

K. Mirror Unit:
   1. Basis-of-Design Product: Bobrick B-290 angled frame.
   2. Frame: Stainless-steel channel.
      a. Corners: Manufacturer's standard.
   3. Hangers: Produce rigid, tamper- and theft-resistant installation, using method indicated below.
      a. One-piece, galvanized-steel, wall-hanger device with spring-action locking mechanism to hold mirror unit in position with no exposed screws or bolts.

b. Wall bracket of galvanized steel, equipped with concealed locking devices requiring a special tool to remove.

4. Size: As indicated on Drawings.

L. Coat Hook and Bumper:
1. Basis-of-Design Product: Bobrick B212.
2. Description: Partition mounted clothes hook and bumper.
3. Material and Finish: Stainless steel, No. 7 finish (polished).

2.3 PUBLIC-USE SHOWER ROOM ACCESSORIES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Bobrick Washroom Equipment, Inc. product indicated on Drawings or comparable product by one of the following:
1. A & J Washroom Accessories, Inc.
2. American Specialties, Inc.
3. Bradley Corporation.
4. GAMCO Specialty Accessories; a division of Bobrick Washroom Equipment, Inc.
5. Tubular Specialties Manufacturing, Inc.

B. Shower Curtain Rod:
1. Basis-of-Design Product: Bobrick B-207x36.
2. Description: 1-inch (25.4-mm) OD; fabricated from nominal 0.0375-inch- (0.95-mm-) thick stainless steel.
3. Mounting Flanges: Stainless-steel flanges designed for exposed fasteners.
4. Finish: No. 4 (satin).

C. Shower Curtain:
1. Basis-of-Design Product: Bobrick 204-2.
2. Size: Minimum 12 inches (305 mm) wider than opening by 72 inches (1828 mm) high.
3. Material: Nylon-reinforced vinyl, minimum 10 oz. (284 g) or 0.008-inch- (0.2-mm-) thick vinyl, with integral antibacterial agent.
4. Color: White.
5. Grommets: Corrosion resistant at minimum 6 inches (152 mm) o.c. through top hem.
6. Shower Curtain Hooks: Chrome-plated or stainless-steel, spring wire curtain hooks with snap fasteners, sized to accommodate specified curtain rod. Provide one hook per curtain grommet.

D. Folding Shower Seat:
1. Basis-of-Design Product: Bobrick B5181.
2. Reversible
3. Mounting Mechanism: Stainless steel, No. 4 finish (satin).

E. Shower Bench:
1. Basis-of-Design Product: ASI #9200.
2. Description: Freestanding bench with stainless steel base and ADA bench seat.
3. Color: Gray (post consumer recycled material)

F. Towel Pin:
1. Basis-of-Design Product: Bobrick B677.
2. Description: Projecting minimum of 3 inches (75 mm) from wall surface.
3. Material and Finish: Stainless steel, No. 7 finish (polished).

G. Coat Hook (Shower Room and Office):
1. Basis-of-Design Product: Doug Mockett & Company, Inc.; #CH23 “Button Coat Hook”.
2. Description: Projecting minimum of 1-3/8 inches from wall surface.
3. Material and Finish: Stainless steel, No. 7 finish (polished).

2.4 UNDERLAVATORY GUARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Plumberex Specialty Products, Inc.
   2. Truebro by IPS Corporation.

B. Underlavatory Guard:
   1. Basis-of-Design Product: Plumberex Handy Shield.
   2. Description: Insulating pipe covering for supply and drain piping assemblies that prevent direct contact with and burns from piping; allow service access without removing coverings.
   3. Material and Finish: Antimicrobial, molded plastic, white.

2.5 CUSTODIAL ACCESSORIES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Bobrick Washroom Equipment, Inc. product indicated on Drawings or comparable product by one of the following:
   a. A & J Washroom Accessories, Inc.
   b. American Specialties, Inc.
   c. Bobrick Washroom Equipment, Inc.
   d. Bradley Corporation.
   e. GAMCO Specialty Accessories; a division of Bobrick Washroom Equipment, Inc.
   f. Tubular Specialties Manufacturing, Inc.

B. Utility Shelf:
   1. Description: With exposed edges turned down not less than 1/2 inch (13 mm) and supported by two triangular brackets welded to shelf underside.
   2. Size: 16 inches (406 mm) long by 6 inches (152 mm) deep.
   3. Material and Finish: Not less than nominal 0.05-inch- (1.3-mm-) thick stainless steel, No. 4 finish (satin).

C. Mop and Broom Holder:
   1. Basis-of-Design Product: Bobrick B223
   2. Description: Unit with shelf, hooks, and holders.
   3. Length: 36 inches (914 mm).
   4. Hooks: Three.
   5. Mop/Broom Holders: Four, spring-loaded, rubber hat, cam type.
   6. Material and Finish: Stainless steel, No. 4 finish (satin).
      a. Shelf: Not less than nominal 0.05-inch- (1.3-mm-) thick stainless steel.

2.6 FABRICATION

A. General: Fabricate units with tight seams and joints, and exposed edges rolled. Hang doors and access panels with full-length, continuous hinges. Equip units for concealed anchorage and with corrosion-resistant backing plates.

B. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to Owner's representative.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install accessories according to manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.

B. Grab Bars: Install to withstand a downward load of at least 250 lbf (1112 N), when tested according to ASTM F 446.

3.2 ADJUSTING AND CLEANING

A. Adjust accessories for unencumbered, smooth operation. Replace damaged or defective items.

B. Remove temporary labels and protective coatings.

C. Clean and polish exposed surfaces according to manufacturer's written recommendations.

END OF SECTION

SECTION 10 44 13

FIRE EXTINGUISHER CABINETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Fire protection cabinets for the following:
      a. Portable fire extinguishers.

B. Related Sections:
   1. Section 10 14 23 "Interior Signage" for directional signage to out-of-sight fire extinguishers and cabinets.
   2. Section 10 44 16 "Fire Extinguishers."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for fire protection cabinets.
   1. Fire Protection Cabinets: Include roughing-in dimensions, details showing mounting methods, relationships of box and trim to surrounding construction, door hardware, cabinet type, trim style, and panel style.
   2. Show location of knockouts for hose valves.

B. Shop Drawings: For fire protection cabinets. Include plans, elevations, sections, details, and attachments to other work.

C. Samples for Initial Selection: For each type of fire protection cabinet indicated.

D. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below:
   1. Size: 6 by 6 inches square.

E. Product Schedule: For fire protection cabinets. Coordinate final fire protection cabinet schedule with fire extinguisher schedule to ensure proper fit and function. Use same designations indicated on Drawings.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For fire protection cabinets to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Fire-Rated, Fire Protection Cabinets: Listed and labeled to comply with requirements in ASTM E 814 for fire-resistance rating of walls where they are installed.

B. Preinstallation Conference: Conduct conference at Project site.
   1. Review methods and procedures related to fire protection cabinets including, but not limited to, the following:
      a. Schedules and coordination requirements.

1.6 COORDINATION

A. Coordinate size of fire protection cabinets to ensure that type and capacity of fire extinguishers indicated are accommodated.

B. Coordinate size of fire protection cabinets to ensure that type and capacity of fire hoses, hose valves, and hose racks indicated are accommodated.

C. Coordinate sizes and locations of fire protection cabinets with wall depths.

1.7 SEQUENCING

A. Apply vinyl lettering on field-painted, fire protection cabinets after painting is complete.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B.

B. FIRE PROTECTION CABINET

C. Cabinet Type: Suitable for fire extinguisher.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Potter Roemer LLC or comparable product by one of the following:
      a. J. L. Industries, Inc., a division of Activar Construction Products Group
      b. Kidde Residential and Commercial Division, Subsidiary of Kidde PLLC
      c. Larsen's Manufacturing Company
      d. Watrous Division, American Specialties, Inc.
   2. Basis of Design Potter Roemer LLC models:
      a. Recessed (FE-R): Dana series; 7220-F
      b. Surface Mounted (FE-S): Alta series; 7009-DV

D. Cabinet Construction: 1-hour fire rated.
   1. Fire-Rated Cabinets: Construct fire-rated cabinets with double walls fabricated from 0.0428-inch-thick, cold-rolled steel sheet lined with minimum 5/8-inch- thick, fire-barrier material. Provide factory-drilled mounting holes.

E. Cabinet Material: Steel sheet.
   1. Shelf: Same metal and finish as cabinet.

F. Cabinet Trim Material: Steel sheet same material as door.

G. Door Material: Steel sheet

H. Door Style:
   1. Recessed: Solid Flush Panel
   2. Surface Mounted: Dou vertical Panel

I. Door Hardware: Manufacturer's standard door-operating hardware of proper type for cabinet type, trim style, and door material and style indicated.
   1. Provide manufacturer's standard.

J. Accessories:
   1. Mounting Bracket: Manufacturer's standard steel, designed to secure fire extinguisher to fire protection cabinet, of sizes required for types and capacities of fire extinguishers indicated, with plated or baked-enamel finish.
   2. Handle (recessed cabinet): Cam handle that allows door to be opened during emergency by pulling sharply on door handle.
   3. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate as directed by Architect.
      a. Identify fire extinguisher in fire protection cabinet with the words "FIRE EXTINGUISHER."

K. Finishes:
   1. Manufacturer's standard baked-enamel paint for the following:
      a. Steel: electrostatically applied, thermally fused polyester coating to match adjacent wall finish.
         1) Color to be selected by the Architect.

2.2 FABRICATION

A. Fire Protection Cabinets: Provide manufacturer's standard box (tub) with trim, frame, door, and hardware to suit cabinet type, trim style, and door style indicated.
   1. Weld joints and grind smooth.
   2. Provide factory-drilled mounting holes.
   3. Prepare doors and frames to receive locks.
   4. Install door locks at factory.

B. Cabinet Doors: Fabricate doors according to manufacturer's standards, from materials indicated and coordinated with cabinet types and trim styles selected.
   1. Fabricate door frames with tubular stiles and rails and hollow-metal design, minimum 1/2 inch thick.
   2. Miter and weld perimeter door frames.

C. Cabinet Trim: Fabricate cabinet trim in one piece with corners mitered, welded, and ground smooth.

2.3 GENERAL FINISH REQUIREMENTS

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

B. Protect mechanical finishes on exposed surfaces of fire protection cabinets from damage by applying a strippable, temporary protective covering before shipping.

C. Finish fire protection cabinets after assembly.

D. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for cabinets to verify actual locations of piping connections before cabinet installation.

B. Examine walls and partitions for suitable framing depth and blocking where recessed and semirecessed cabinets will be installed.

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

3.2 PREPARATION

A. Prepare recesses for semirecessed fire protection cabinets as required by type and size of cabinet and trim style.

3.3 INSTALLATION

A. General: Install fire protection cabinets in locations and at mounting heights indicated or, if not indicated, at heights acceptable to authorities having jurisdiction.
   1. Fire Protection Cabinets: 54 inches above finished floor to top of cabinet.

B. Fire Protection Cabinets: Fasten cabinets to structure, square and plumb.
   1. Provide recessed and surface mounted fire protection cabinets in locations indicated on the Drawings.. If wall thickness is not adequate for recessed cabinets, provide semirecessed fire protection cabinets.
   2. Fasten mounting brackets to inside surface of fire protection cabinets, square and plumb.
   3. Fire-Rated, Cabinets:
      a. Install cabinet with not more than 1/16-inch tolerance between pipe OD and knockout OD. Center pipe within knockout.
      b. Seal through penetrations with firestopping sealant as specified in Section 07 84 13 "Penetration Firestopping."

C. Identification: Apply vinyl lettering at locations indicated.

3.4 ADJUSTING AND CLEANING

A. Remove temporary protective coverings and strippable films, if any, as fire protection cabinets are installed unless otherwise indicated in manufacturer's written installation instructions.

B. Adjust fire protection cabinet doors to operate easily without binding. Verify that integral locking devices operate properly.

C. On completion of fire protection cabinet installation, clean interior and exterior surfaces as recommended by manufacturer.

D. Touch up marred finishes, or replace fire protection cabinets that cannot be restored to factory-finished appearance. Use only materials and procedures recommended or furnished by fire protection cabinet and mounting bracket manufacturers.

E. Replace fire protection cabinets that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION

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SECTION 10 44 16

FIRE EXTINGUISHERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes portable, fire extinguishers.

B. Owner-Furnished Material: fire extinguishers.

1.3 QUALITY ASSURANCE

A. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10, "Portable Fire Extinguishers."

B. Fire Extinguishers: Listed and labeled for type, rating, and classification by an independent testing agency acceptable to authorities having jurisdiction.
   1. Provide fire extinguishers approved, listed, and labeled by FMG.
   2. COORDINATION

C. Coordinate type and capacity of fire extinguishers with fire protection cabinets to ensure fit and function.

PART 2 - PRODUCTS

2.1 PORTABLE, HAND-CARRIED FIRE EXTINGUISHERS

A. Fire Extinguishers: Type, size, and capacity for each fire protection cabinet and mounting bracket indicated.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Buckeye Fire Equipment Company.
      b. J. L. Industries, Inc.; a division of Activar Construction Products Group.
      c. Kidde Residential and Commercial Division; Subsidiary of Kidde plc.
      d. Larsen's Manufacturing Company.
      e. Potter Roemer LLC.

B. Multipurpose Dry-Chemical Type: UL-rated 10 lb nominal capacity, with monoammonium phosphate-based dry chemical in manufacturer's standard enameled container.

C. Color: White

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fire extinguishers for proper charging and tagging.
   1. Remove and replace damaged, defective, or undercharged fire extinguishers.

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

3.2 INSTALLATION

A. General: Install fire extinguishers in locations indicated and in compliance with requirements of authorities having jurisdiction.

END OF SECTION

SECTION 10 82 00

TREILLAGE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Exterior Trellis Panels.

1.2 RELATED REQUIREMENTS

A. Section 03 30 00 - Cast-in-Place Concrete.

B. Section 09 96 00 – High-Performance Coatings.

C. Section 32 93 00 – Planting.

1.3 REFERENCES STANDARDS:

A. ASTM A500 – Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

B. ASTM A82 – Standard Specification for Steel Wire, Plain for Concrete Reinforcement

C. ASTM A641 – Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire

D. ASTM A879 – Standard Specification for Steel Sheet, Zinc Coated by the Electrolytic Process for Applications Requiring Designation of the Coating Mass on Each Surface.

E. ASTM B117 – Standard Practice for Operating Salt Spray (Fog) Apparatus.

F. ASTM A856/ A856M – Standard Specification for Zinc – 5% Aluminum Misch metal alloy coated steel wire.

G. ASTM A123 – Standard Specification for Zinc (Hot Dip Galvanizing) Coatings on Steel Products.

H. ANSI/AWS A2.4-79 – Welding Symbols Descriptions and Standards.

I. Structural Code of the International Building Code (IBC), 2009.

J. ASCE7 – Standard for Wind Load Calculations.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordinate fabrication of metal mesh with fabrication of work on or in which the panels will be installed.

B. Providing final size measurements to manufacture in time to avoid delay in the construction schedule.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: Submit manufacturer's product data, standard details, details unique to this installation and installation instructions.

C. Shop Drawings: Submit elevations and plan drawings indicating the following:
   1. Wire series and pattern name.
   2. Panel sizes and layout
   3. Panel thickness.
   4. Attachment bracket details.
   5. Registered Structural Engineer stamp verifying that panels and post design and connections conform to the standards of IBC and ASCE7.

D. LEED Submittals
   1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
      a) Include statement indicating cost for each product having recycled content.
   2. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.

E. Verification Samples: Finishes for selection. For each finish product specified, two samples, minimum size 12 inches square, represent actual product and finish.

F. Paint Color: Colors for selection from manufacturer's standard colors.

G. Manufacturer's Certificates: Certify products meet or exceed specified requirements.

H. Warranty: Submit manufacture warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience. Having successfully completed projects within that time of similar size, complexity, and utilizing similar systems.

B. Installer Qualifications: Experienced in performing work of this section that has specialized in installation of work similar to that required for this project.

C. Preinstallation Meetings: Conduct meeting including Contractor, Architect, manufacturer, installer and other subcontractors whose work involves metal grille and screen systems to verify project requirements, framing and support conditions, mounting surfaces and manufacturer's installation requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

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

B. Store products wrapped or otherwise protected and under clean and dry storage conditions until required for installation.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Basis of Design Product: 'Living Screen' by The Western Group, DuPont, WA; Tel: 952.947.9093 or 952.220.2680 (GSR Group Inc.); Email: gfast@gsrgroupinc.com Web: www.architecturalwire.com
   1. Material: 10 gauge welded wire. Select material below.
   2. Width and Length: (Refer to drawings).
   3. Grid Type: S Slot Mesh Type 1" x 3"
   4. Truss size: 3-inch deep. Truss is to be a ladder of corresponding size to the grid that maintains continuous contact with and welded to both front and back grid panels.
   5. Wire Gauge: 10-gauge.
   6. Tolerance: 1/4 inch in width and 1/4 inch in length.
   7. ¾" & 2-3/8" CC inline hole pattern perforated plate

B. Finishes: Panels:
   1. Stainless Steel:
      a. Type 316.
      b. Satin finish.

C. Finishes: For Steel Post, Cap, Flashing, Angle, Channel:
   1. Refer to Section 09 96 00 High-Performance Coatings for shop applied coatings

2.4 ATTACHMENT SYSTEMS

A. Fence Post: Steel tube with post caps. See Structural Drawings for materials and sizing.

B. Angle: 2" x 2" x ¼" steel angle continuous. Nutserts to be factory installed for mounting panels to angle.

C. Fasteners for Mounting Panels to Angle: Type 410 stainless steel bolt, flat washer and lock washer, free from rust when salt spray tested for 300 hours in accordance with ASTM B117.

2.5 TRIM

A. Fabricate from 16 - gauge (Finish) steel.

B. Types:
   1. Channel Trim: Thickness of Panel x 1" legs.
   2. Locations:
      a. Top of Treillage: Standard Channel.
      b. Side of Treillage: Custom U flashing as noted in Drawings.

c. Bottom of Treillage: Angle Trim

2.6 FABRICATION

A. Fabricate Living Screen panels in accordance with approved shop drawings.
B. Fabricate compatible attachment system to satisfy structural and performance requirements.
C. Shop apply painted finishes after completion of all welds and panel to post installation per Section 09 96 00.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine work area with installer present for compliance with site preparation and work of others required for successful installation of fence.

B. Verify dimensions, tolerances, and method of attachment with other work on-site.

C. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

D. Do not begin installation until openings and substrates have been properly prepared to receive the products of this section.

3.2 PREPARATION

A. Locate line of trellis or fence. Mark utilities, irrigation lines etc. Verify location with site survey if near site boundary or property line.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide suitable means of anchorage acceptable to manufacturer such as dowels, anchor clips, bar anchors, expansion bolts and shields, and toggles.

C. Anchor supports securely with allowance for necessary thermal movement and structural support.

D. Erect metalwork square, plumb, straight, and true, accurately fitted, with tight joints and intersections.

E. Do not install component parts that are observed to be defective, including warped, bowed, dented, abraded and broken members.

F. Do not cut, trim, weld or braze component parts during erection in manner that would damage finish, decrease strength, or result in visual imperfection or failure in performance. Return component parts that require alteration to shop for refabrication, if possible, or for replacement with new parts.

G. Separate dissimilar metals and use gasketed fasteners, isolation shim, or isolation tape to eliminate possibility of corrosive or electrolytic action between metals.

3.4 PROTECTION

A. Protect installed products until completion of project.

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

End Of Section

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SECTION 11 13 00

LOADING DOCK EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Dock levelers.
2. Truck restraints.
3. Dock bumpers.

B. Related Sections:
1. Section 03 30 00 "Cast-in-Place Concrete" for concrete work for recessed loading dock equipment.
2. Section 05 50 00 "Metal Fabrications" for curb angles at edges of recessed pits and loading dock platform edge channels.
3. Section 08 33 23 "Overhead Coiling Doors" for coiling and other overhead doors electrically interlocked to dock levelers.

1.3 DEFINITIONS

A. Operating Range: Maximum amount of travel above and below the loading dock level.

B. Working Range: Recommended amount of travel above and below the loading dock level for which loading and unloading operations can take place.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for loading dock equipment. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For loading dock equipment. Include plans, elevations, sections, details, and attachments to other work.
1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Samples for Initial Selection: For each type of dock-seal fabric indicated.

D. Samples for Verification: For each type of dock-seal fabric indicated.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Welding certificates.

C. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency; indicate compliance of dock levelers with requirements in MH 30.1 for determining rated capacity, which is based on comprehensive testing within last two years of current products.
   1. Submittal Form: According to MH 30.1, Appendix A.

D. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For loading dock equipment to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
   1. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.

B. Source Limitations: Obtain loading dock equipment from single source from single manufacturer.

C. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
   2. AWS D1.3, "Structural Welding Code - Sheet Steel."

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Preinstallation Conference: Conduct conference at Project site.
   1. Inspect and discuss electrical roughing-in, equipment bases, and other preparatory work specified elsewhere.
   2. Review sequence of operation for each type of loading dock equipment.
   3. Review coordination of interlocked equipment specified in this Section and elsewhere.
   4. Review required testing, inspecting, and certifying procedures.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store and handle dock seals in a manner to avoid significant or permanent damage to fabric or frame.
   1. Comply with manufacturer's written instructions for minimum and maximum temperature requirements for storage.

1.9 PROJECT CONDITIONS

A. Field Measurements: Verify actual dimensions of construction contiguous with loading dock equipment, including recessed pit dimensions and heights of loading docks, by field measurements before fabrication.

1.10 WARRANTY

A. Special Warranty for Dock Levelers: Manufacturer's standard form in which manufacturer agrees to repair or replace dock-leveler components that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures including cracked or broken structural support members, load-bearing welds, and front and rear hinges.
      b. Faulty operation of operators, control system, or hardware.
      c. Deck plate failures including cracked plate or permanent deformation in excess of 1/4 inch between deck supports.
      d. Hydraulic system failures including failure of hydraulic seals and cylinders.

   2. Warranty Period for Structural Assembly: 10 years from date of Substantial Completion.
   3. Warranty Period for Hydraulic System: Five years from date of Substantial Completion.
   4. Warranty shall be for unlimited usage of leveler for the specified rated capacity over the term of the warranty.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel Plates, Shapes, and Bars: ASTM 36/A 36M.

B. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from steel plate complying with ASTM A 572/A 572M, Grade 55.

C. Steel Tubing: ASTM A 500, cold formed.

D. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

2.2 RECESSED DOCK LEVELERS

A. General: Recessed, hinged-lip-type dock levelers designed for permanent installation in concrete pits preformed in the edge of loading platform; of type, function, operation, capacity, size, and construction indicated; and complete with controls, safety devices, and accessories required.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Rite-Hite Corporation; Leveler Model #RHH4087 or comparable product by one of the following:
      a. Beacon Industries, Inc.
      b. Blue Giant Equipment Corporation.

B. Standard: Comply with MH 30.1, except for structural testing to establish rated capacity.

C. Rated Capacity: Capable of supporting total gross load of <Insert capacity> without permanent deflection or distortion.

D. Platform: Not less than 1/4-inch thick, nonskid steel plate.
   1. Platform Size: As indicated on Drawings.
   2. Frame: Manufacturer's standard.
   3. Toe Guards: Equip open sides of dock leveler over range indicated with metal toe guards.
      a. Toe-Guard Range: Entire upper operating range.

E. Hinged Lip: Not less than 1/2-inch thick, nonskid steel plate.
   1. Hinge: Full width, piano-type hinge with heavy-wall hinge tube and greased fittings, with gussets on lip and ramp for support.
   2. Safety Barrier Lip: Designed to protect material-handling equipment from an accidental fall from loading platform edge of the dock leveler when the leveler is not in use.

F. Function: Dock levelers shall compensate for differences in height between truck bed and loading platform.
   1. Vertical Travel: Operating range above platform level of sufficient height to enable lip to extend and clear truck bed before contact with the following minimum working range:
      a. Above Adjoining Platform: 12 inches.
      b. Below Adjoining Platform: 12 inches
   2. Automatic Vertical Compensation: Floating travel of ramp with lip extended and resting on truck bed shall compensate automatically for upward or downward movement of truck bed during loading and unloading.
   3. Automatic Lateral Compensation: Tilting of ramp with lip extended and resting on truck bed shall compensate automatically for canted truck beds of up to 4 inches over width of ramp.
   4. Lip Operation: Manufacturer's standard mechanism that automatically extends and supports hinged lip on ramp edge with lip resting on truck bed over dock leveler's working range, allows lip to yield under impact of incoming truck, and automatically retracts lip when truck departs.
      a. Length of Lip Extension: 16 inches.
   5. Interlock: Leveler will not operate while truck restraint is not engaged.

G. Hydraulic Operating System: Electric control from a remote-control station; fully hydraulic operation. Electric-powered hydraulic raising and hydraulic lowering of ramp. Equip leveler with a packaged unit including a unitized, totally enclosed, nonventilated electric motor, pump, manifold reservoir, and valve assembly of proper size, type, and operation for capacity of leveler indicated. Include means for lowering ramp below platform level with lip retracted behind dock bumpers. Provide a hydraulic velocity fuse connected to main hydraulic cylinder to limit loaded ramp's free fall to not more than 3 inches (76 mm).
   1. Remote-Control Station with Emergency Stop: Weatherproof multibutton control station with an UP button of the constant-pressure type and an emergency STOP button of the momentary-contact type, enclosed in NEMA ICS 6, Type 4 box. Ramp raises by depressing and holding UP button; ramp lowers at a controlled rate by releasing UP button. All ramp movement stops, regardless of position of ramp or lip, by depressing STOP button. Normal operation resumes by engaging a manual reset button or by pulling out STOP button.
      a. Master Panel: Control panel with integral fused disconnecting means for operating dock leveler, dock door, and truck restraints.
   2. Independent Lip Operation: Electric-powered hydraulic raising and hydraulic lowering of lip, controlled independent of raising and lowering of ramp.
   3. Electrical: ¾ HP motor rated at 208/60 Hz, three phase

H. Construction: Fabricate dock-leveler frame, platform supports, and lip supports from structural- or formed-steel shapes. Weld platform and hinged lip to supports. Fabricate entire assembly to withstand deformation during both operating and stored phases of service. Chamfer lip edge to minimize obstructing wheels of material-handling vehicles.
   1. Cross-Traffic Support: Manufacturer's standard method of supporting ramp at platform level in stored position with lip retracted. Provide a means to release supports to allow ramp to descend below platform level.
   2. Maintenance Strut: Integral strut to positively support ramp in up position during maintenance of dock leveler.

I. Integral Laminated-Tread Dock Bumper: Fabricated from 4-1/2-inch- - thick, multiple, uniformly thick plies cut from fabric-reinforced rubber tires. Laminate plies under pressure on not less than two 3/4-inch-diameter, steel supporting rods that are welded at one end to 1/4-inch- thick, structural-steel end angle and secured with a nut and angle at the other end. Fabricate angles with predrilled anchor holes and sized to provide not less than 1 inch of tread plies extending beyond the face of closure angles.

J. Accessories:
1. Curb Angles: 3-by-3-by-1/4-inch galvanized-steel curb angles for edge of recessed leveler pit, with 1/2-inch- diameter by 6-inch- long concrete anchors welded to angle at 6 inches o.c.
2. Self-Forming Pan: Manufacturer's standard prefabricated, self-forming steel form system for poured-in-place construction of concrete pit.
3. Abrasive skid-resistant surface.
4. Finish: Paint dock levelers after assembly and testing.
5. Toe Guards: Paint yellow to comply with ANSI Z535.1.

2.3 TRUCK RESTRAINTS

A. General: Manufacturer's standard device designed to engage truck's rear-impact guard and hold truck at loading dock. Restraint shall consist of an iron or steel restraining arm that rises until contacting rear-impact guard. Arm shall move vertically, automatically adjusting to varying height of truck due to loading and unloading operations.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Beacon Industries, Inc.
b. Blue Giant Equipment Corporation.
c. Rite-Hite Corporation.

B. Standard: Comply with MH 30.3.

C. Restraining capacity of restraints varies from 20,000 to 55,000 lb (9072 to 24 948 kg). Verify available capacity with manufacturers.

D. Operating range of restraints typically varies from 12 to 30 inches (305 to 762 mm). Verify available operating range with manufacturers.

E. Operating Range: Capable of restraining rear-impact guards within a range from:
1. Vertical: As indicated on Drawings above driveway.
2. Horizontal: As indicated on Drawings in front of dock bumpers.

F. Power Operating System: Manufacturer's standard electromechanical or hydraulic unit.

G. Caution Signs: Exterior, surface mounted; designed to inform both dock attendant and truck driver; with sign copy as follows. Provide one sign at each truck-restraint location.
1. Sign Copy in Forward and Reverse Text: Manufacturer's standard text permitting truck movement with green light.

H. Light-Communication System: Red and green illuminated signal-light sets, with lens approximately 4 inches in diameter, designed to indicate status to both dock attendant and truck driver. Equip system with steel control panel located at interior of dock that includes illuminated lights indicating status of exterior signal lights. Provide signal-light set and control panel at each location indicated for light-communication system. Enclose exterior signal-light sets in steel or plastic housing with sunshade.
1. Automatic Operation: System is activated automatically when device engages rear-impact guard. Provide on-off switch located on truck-restraint control panel.
2. Mounting: Wall .

I. Accessories: Interlock to dock leveler.

J. Truck-Restraint Finish: Painted.

2.4 DOCK BUMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
1. American Floor Products Company, Inc.
2. Beacon Industries, Inc.
3. Rite-Hite Corporation.

B. Laminated-Tread Dock Bumper : Fabricated from multiple, uniformly thick plies cut from fabric-reinforced rubber tires. Laminate plies under pressure on not less than two 3/4-inch- diameter, steel supporting rods that are welded at one end to 1/4-inch- thick, structural-steel end angle and secured with a nut and angle at the other end. Fabricate angles with predrilled anchor holes and sized to provide not less than 1 inch of tread plies extending beyond the face of closure angles.
1. Thickness: 4-1/2 inches .
2. Vertical Style: 8 inches wide by 20 inches high .

C. Anchorage Devices: Hot-dip galvanized-steel anchor bolts, nuts, washers, bolts, sleeves, cast-in-place plates, and other anchorage devices as required to fasten bumpers securely in place and to suit installation type indicated.

2.5 GENERAL FINISH REQUIREMENTS

A. Finish loading dock equipment after assembly and testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of loading dock equipment.

B. Examine roughing-in for electrical systems for loading dock equipment to verify actual locations of connections before equipment installation.

C. Examine walls and floors of pits for suitable conditions where recessed loading dock equipment is to be installed. Pits shall be plumb and square and properly sloped for drainage from back to front of loading dock.

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

3.2 PREPARATION

A. Coordinate size and location of loading dock equipment indicated to be attached to or recessed into concrete or masonry, and furnish anchoring devices with templates, diagrams, and instructions for their installation.

B. Set curb angles in concrete edges of dock-leveler recessed pits with tops flush with loading platform. Fit exposed connections together to form hairline joints.

C. Set curb angles in concrete edges of truck-leveler recessed pits with tops flush with driveway. Fit exposed connections together to form hairline joints.

D. Place self-forming pan system for recessed dock levelers in proper relation to loading platform before pouring concrete.

E. Clean recessed pits of debris.

3.3 INSTALLATION

A. General: Install loading dock equipment, including motors pumps control stations wiring safety devices light-communication systems and accessories as required for a complete installation.
   1. Rough-in electrical connections.

B. Recessed Dock Levelers: Attach dock levelers securely to loading dock platform, flush with adjacent loading dock surfaces and square to recessed pit.

C. Truck Restraints: Attach truck restraints in a manner that complies with requirements for arrangement and height required for device to engage vehicle rear-impact guard. Interconnect control panel and signals with dock leveler.
   1. Wall-Mounted Units: Anchor truck restraints to face of loading dock with expansion anchors and bolts.

D. Dock Bumpers: Attach dock bumpers to face of loading dock in a manner that complies with requirements indicated for spacing, arrangement, and position relative to top of platform and anchorage.
   1. Bolted Attachment: Attach dock bumpers to preset anchor bolts embedded in concrete or to cast-in-place inserts or threaded studs welded to embedded-steel plates or angles. If preset anchor bolts, cast-in-place inserts, or threaded studs welded to embedded-steel plates or angles are not provided, attach dock bumpers by drilling and anchoring with expansion anchors and bolts.

3.4 ADJUSTING

A. Adjust loading dock equipment to function smoothly and safely, and lubricate as recommended by manufacturer.

B. Test dock levelers for vertical travel within operating range indicated.

C. After completing installation of exposed, factory-finished loading dock equipment, inspect exposed finishes and repair damaged finishes.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain loading dock equipment.

END OF SECTION

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SECTION 11 23 00

WASHING AND DRYING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Glassware Washer / Dryer Combination

1.2 RELATED DOCUMENTS

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

B. Division 01 – Sustainable Design Requirements.

C. Division 22 – Plumbing Requirements

D. Division 23 – HVAC Requirements

E. Division 26 – Electrical Requirements

F. Related Work Specified Elsewhere
1. Final connection to services are specified in Divisions 21 through 28 and indicated on the Mechanical, Electrical, and Plumbing drawings.
2. Related Section, 11 71 00 – Sterilizing Equipment

1.3 REFERENCES

A. American National Standards Institute (ANSI)
1. ANSI/UL 3101.1 – Electrical Equipment for Laboratory Use: General Requirements.

B. Underwriters Laboratories, Inc. (UL)
1. 1262 - Laboratory Equipment
2. 544 - Medical and Dental Equipment

C. American Society of Testing Materials (ASTM)
1. A167 – Stainless Steel, Alloy 302 or 304.

1.4 PROJECT CONDITIONS

A. Field Measurements
1. Take field measurements to verify or supplement dimensions indicated. Be responsible for accurate fit of the Work.
2. Verify that all equipment in this section is coordinated to provide a complete working process and system integration

B. Utilities Verification
1. Utilities and connections may vary between approved manufacturers.

2. All utilities for these items are indicated in mechanical and electrical documents and are referenced in Divisions 15 and 16 / 21 through 28. Any deviations from these utilities must be documented within bid and shop drawing submittals.

1.5 WARRANTY

1. Manufacturer will repair or replace, at no cost to the Owner, any defective components or system, including all labor and material and for a period of (1) one year, unless noted otherwise, from date of operational acceptance by the Owner.
2. Date of operational acceptance shall be after factory check, test and start-up service is complete, the unit is operating in a satisfactory manner, and the equipment has been satisfactorily commissioned by the Owner. The operational acceptance date shall be obtained in writing from the Owner.
3. Owner will perform routine maintenance as described in the Manufacturers Standard Operation and Maintenance manuals during the warranty period. Owner's performance shall in no way invalidate said warranties.

1.6 ACTION SUBMITTALS

A. Shop Drawings
1. Submit shop drawings showing layout and details of fabrication and installation, including utility connections, wiring diagrams, and motor horsepower.
   a. Models indicated in this section to include all standard features listed in latest catalog or website at date of submittal

1.7 CLOSEOUT SUBMITTALS

A. Operations and Maintenance Data
1. Submit operations and maintenance instructions

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Units must conform to the Uniform Plumbing Code and the National Electrical Code.

B. All mechanical and electrical components shall comply with the requirement of Divisions 21 through 28.

2.2 MANUFACTURER

A. Lancer USA, 1700LXA

B. Products of the following manufacturers are acceptable provided they meet the criteria of these specifications:
1. Getinge / Castle, Inc.
2. Steris Corporation
3. Miele, Inc.

C. The Contract Sum shall include costs related to:
1. Modifications, recommended by the manufacturer for proper installation and performance of products, to intended building construction and utilities.
2. Coordination required to perform the modifications.

2.3 GLASSWARE WASHER / DRYER COMBINATION (EQ-001)

A. Configuration and Features: A freestanding, steam heated, cabinet type washer with built in dryer function used for the cleaning of laboratory glassware, plastic and metal goods. Minimum wash chamber size of 30”H x 25”W x 28”D and maximum overall cabinet size of 80”H x 36”W x 44”D Include the following features:
1. Stainless steel enclosure cabinet – no recess.
2. Stainless steel frame assembly.
3. Powered vertical sliding chamber door, with viewing window.
4. Interior chamber light.
5. Microprocessor control system incorporating a minimum of 3 pre-programmed adjustable wash cycles of light, medium and heavy use. Storage capacity of 7 custom wash programs and cycles. 2 preprogrammed decaling and priming cycles.
6. Programmable drying cycle capable of delivering 240 degrees F, (116 degrees C). circulated chamber air temperatures.
7. Service capability from front of unit.
8. Electric heated pure water rinse cycle/tank.
9. Provide non-vented vapor condenser designed to achieve 75 degrees F 50 percent RH down-side exhaust.
10. Drain discharge cool down and cold water pre-wash.
11. Integral drying system – steam to be evacuated from chamber prior to door opening
12. System wash levels
13. Water level sensors
14. Reduced water consumption features

B. ACCESSORIES
1. Each unit shall include the following:
   a. Manual Transfer/Load Trolley (With and without drain assembly)
   b. Glassware Injection Cart, 2 levels (with removable upper levels)
   c. (4) Removable 4x8 Glass Cassette
   d. (4) Removable 3x6 Glass Cassette
   e. 2 Level Glassware Wash Cart Blanking Plate-Left
   f. 2 Level Glassware Wash Cart Blanking Plate-Right
   g. One level Glassware Injection Cart Kit

C. UNIT REQUIREMENTS (Design Model)
1. Hot Water - ¾” NPT, 29-87 PSIG dynamic, maximum 90 psig static, 122 degrees F minimum. Minimum 5.25 gal/min. maximum 7.5 gal/min. flow rate.
2. Cold Water – ¾” NPT, 29-87 psig dynamic, maximum 90 psig static, 60 degrees F maximum. Minimum 5.25 gal/min. maximum 7.5 gal/min. flow rate
3. Reagent Grade Water – ¾” NPT, 29 - 87 psig dynamic, maximum 90 psig static., Minimum 5.25” gal/min. maximum 7.5 gal/min. flow rate.
4. Condensate Return – ½” NPT, 1 gpm peak flow rate.
5. Drain – min. 2” NPT a 4” floor funnel or open drain and a 4” floor sink recommended, maximum 15 gal/min. flow rate. Pump drain maximum 90 gal/min. flow rate
6. Electricity – 480 Volts, 60 Hz., 3 Phase, 21 A/phase service requirement for single connection.
7. Compressed air – 1/8” NPT,59 dynamic to 125 static psig, flow rate 1 scfm, maximum particle size 40 microns, maximum particle density 10 mg/m^3, maximum dew point for water content 45 degree F, maximum oil concentration for oil content 25 mg/m^3 as per ISO 8573-1, Class 5.
8. Data connection required

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the Work completely, and in accordance with manufacturer's instructions and approved Shop Drawings and under the supervision of the manufacturer's representative.

B. Touch up damaged finishes equal to original condition as approved. Make final adjustments required for proper operation as determined by the Architect.

C. Test all unit functions. Provide a dated report to Owner’s representative certifying that the unit functions properly.

3.2 DEMONSTRATION

A. The manufacturer shall provide four copies of operation manual describing equipment operating and routine maintenance service procedures. Instruct the Owner’s designated representatives in these procedures during the startup and test period.

B. Training
   1. Training shall be a 1-day (6 hours), 2 sessions per model minimum.
   2. Training shall be conducted by a factory authorized service representative when mutually agreed to with the Owner.

END OF SECTION

SECTION 11 31 00

RESIDENTIAL APPLIANCES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Refrigeration appliances.
   a. Full size, side by side refrigerator freezer
   b. Under counter icemaker
   c. Under counter refrigerator
2. Cleaning appliances.
3. Microwave.

B. Related Sections:
1. Division 22 Section "Plumbing Fixtures" for kitchen sinks, waste disposers, and instant hot-water dispensers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, dimensions, furnished accessories, and finishes for each appliance.

B. LEED Submittals:
1. Product Data for Credit EA 1.4: For appliances indicated; documentation that products are ENERGY STAR rated.

C. Samples: For each exposed product and for each color and texture specified, in manufacturer's standard size.

D. Product Schedule: For appliances. Use same designations indicated on Drawings.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Product Certificates: For each type of appliance, from manufacturer.

C. Field quality-control reports.

D. Warranties: Sample of special warranties.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each residential appliance to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer for installation and maintenance of units required for this Project.

B. Source Limitations: Obtain residential appliances from single source and each type of residential appliance from single manufacturer.

C. Regulatory Requirements: Comply with the following:
   1. NFPA: Provide electrical appliances listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Accessibility: Where residential appliances are indicated to comply with accessibility requirements, comply with the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and ICC/ANSI A117.1.

E. Preinstallation Conference: Conduct conference at Project site.

1.7 WARRANTY

A. Microwave Oven: Full warranty including parts and labor for on-site service on the magnetron tube.
   1. Warranty Period: Two years from date of Substantial Completion.

B. Refrigerator/Freezer, Sealed System: Full warranty including parts and labor for on-site service on the product.
   1. Warranty Period for Sealed Refrigeration System: Two years from date of Substantial Completion.

C. Dishwasher: Full warranty including parts and labor for on-site service on the product.
   1. Warranty Period for Deterioration of Tub and Metal Door Liner: Three years from date of Substantial Completion.
   2. Warranty Period for Other Components: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 REFRIGERATOR/FREEZERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated or comparable product by one of the following:
   1. General Electric Company (GE). (Basis of Design)
   2. Jenn-Air; a division of Whirlpool Corporation.
   3. KitchenAid; a division of Whirlpool Corporation.
   4. LG Appliances.

B. Refrigerator/Freezer: Two-door refrigerator/freezer with freezer on top and complying with AHAM HRF-1.
   1. Basis-of-Design Product: GE Energy Star 21.0 Cu. Ft. Stainless Steel Top-Freezer Refrigerator (Model # GTH21SCXSS).
   2. Type: Freestanding.
   3. Dimensions:
      a. Width: 32-3/4 inches.
      b. Depth: 32-1/2 inches.
      c. Height: 66-3/4 inches

4. Storage Capacity:
   a. Refrigeration Compartment Volume: 14.9 cu. ft.
   b. Freezer Volume: 6.1 cu. ft.
   c. Shelf Area: Four adjustable glass shelves, 24.5 sq. ft.
5. Refrigerator Features:
   a. Interior light in refrigeration compartment.
   b. Compartment Storage: vegetable crisper and meat compartment.
   c. Door Storage: Modular compartments.
6. Freezer Features: One freezer compartment(s) with door.
   a. Automatic defrost.
7. Energy Performance, ENERGY STAR: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.
8. Front Panel(s): Stainless steel.

C. Under counter icemaker (coffee bar):
   1. under counter ice maker with stainless steel finish
   2. Basis-of-Design Product: Hoshizaki America, Inc. (model # AM-50BAE-AD).

D. Under counter refrigerator (coffee bar):
   1. under counter refrigerator
   2. Basis-of-Design Product: Marvel (model # 6ADAM).

2.2 DISHWASHERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated or comparable product by one of the following:
   1. Amana; a division of Whirlpool Corporation.
   2. BOSCH Home Appliances.
   3. General Electric Company (GE). (Basis of Design)
   4. KitchenAid; a division of Whirlpool Corporation.
   5. LG Appliances.

B. Dishwasher: Complying with AHAM DW-1 and ASSE 1006.
   1. Basis-of-Design Product: GE Built-In Dishwasher with Hidden Controls (Model # GLDT696TSS).
   2. Type: Built-in undercounter.
   3. Dimensions:
      a. Width: 24 inches.
      b. Depth: 24 inches.
      c. Height: 32-11/32 inches.
   4. Capacity:
      a. Water Consumption for Full Load: 3.2 gal. (12 L) per cycle.
   5. Sound Level: Maximum 56 dB.
   6. Tub and Door Liner: Stainless steel with sealed detergent and automatic rinsing-aid dispensers.
   7. Rack System: Nylon-coated sliding dish racks, with removable cutlery basket.
   8. Controls: Touch-pad controls with 7 wash cycles and hot-air and heat-off drying cycle options.
   9. Energy Performance, ENERGY STAR: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.
   10. Front Panel: Stainless steel.

2.3 MICROWAVE OVENS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated or comparable product by one of the following:
   1. General Electric Company (GE).
   2. KitchenAid; a division of Whirlpool Corporation.
   3. LG Appliances.

B. Microwave Oven:
   1. Basis-of-Design Product: GE 1.8 Cu. Ft. Countertop Microwave Oven (Model # JEB1860SMSS).
   2. Mounting: Countertop.
   3. Type: Conventional.
   4. Dimensions:
      a. Width: 24 inches.
      b. Depth: 18-3/4 inches.
      c. Height: 14 inches.
   5. Capacity: 1.8 cu. ft. (0.06 cu. m).
   6. Oven Door: Door with observation window and push-button latch release.
   7. Microwave Power Rating: 1100 W.
   8. Electric Power Supply: 120 V, 60 Hz, 1 phase, 15 A.
   9. Controls: Digital panel controls and timer display.
   10. Material: Stainless steel.

2.4 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances, power connections, and other conditions affecting installation and performance of residential appliances.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before appliance installation.

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

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

3.2 INSTALLATION, GENERAL

A. General: Comply with manufacturer's written instructions.

B. Built-in Equipment: Securely anchor units to supporting cabinets or countertops with concealed fasteners. Verify that clearances are adequate for proper functioning and that rough openings are completely concealed.

C. Freestanding Equipment: Place units in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.

D. Range Anti-Tip Device: Install at each range according to manufacturer's written instructions.

E. Utilities: See Divisions 22 and 26 for plumbing and electrical requirements.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Perform visual, mechanical, and electrical inspection and testing for each appliance according to manufacturers' written recommendations. Certify compliance with each manufacturer's appliance-performance parameters.
   2. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After installation, start units to confirm proper operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and components.

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

D. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain residential appliances.

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SECTION 11 52 13

PROJECTION SCREENS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Electrically operated projection screens and controls.

B. Related Sections:
   1. Division 05 Section "Metal Fabrications" for metal support framing for projection screens.
   2. Division 26 Sections for electrical service and connections including device boxes for switches and conduit, where required, for low-voltage control wiring.

1.3 DEFINITIONS

A. Gain of Front-Projection Screens: Ratio of light reflected from screen material to that reflected perpendicularly from a magnesium carbonate surface as determined per SMPTE RP 94.

B. Half-Gain Angle: The angle, measured from the axis of the screen surface to the most central position on a perpendicular plane through the horizontal centerline of the screen where the gain is half of the peak gain.

1.4 ACTION SUBMITTALS

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

B. Shop Drawings: For projection screens. Show layouts and types of projection screens. Include the following:
   1. For electrically operated projection screens and controls:
      a. Location of screen centerline relative to ends of screen case.
      b. Location of wiring connections for electrically operated units.
      c. Location of seams in viewing surfaces.
      d. Drop lengths.
      e. Anchorage details, including connection to supporting structure for suspended units.
      f. Details of juncture of exposed surfaces with adjacent finishes.
      g. Accessories.
      h. Wiring diagrams.

C. Samples for Initial Selection: For finishes of surface-mounted screen cases.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For projection screens to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Source Limitations for Projection Screens: Obtain projection screens from single manufacturer. Obtain accessories, including necessary mounting hardware, from screen manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.7 DELIVERY, STORAGE, AND HANDLING

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

1.8 COORDINATION

A. Coordinate layout and installation of projection screens with adjacent construction, including ceiling suspension systems, light fixtures, HVAC equipment, fire-suppression system, and partitions.

PART 2 - PRODUCTS

2.1 ELECTRICALLY OPERATED PROJECTION SCREENS

A. General: Manufacturer's standard units consisting of case, screen, motor, controls, mounting accessories, and other components necessary for a complete installation. Provide units that are listed and labeled as an assembly by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.
   1. Controls: Remote, three-position control switch installed in recessed device box with flush cover plate matching other electrical device cover plates in room where switch is installed.
      a. Provide number of control switches indicated for each screen.
      b. Provide power supply for low-voltage systems if required.
   2. Motor in Roller: Instant-reversing motor of size and capacity recommended by screen manufacturer; with permanently lubricated ball bearings, automatic thermal-overload protection, preset limit switches to automatically stop screen in up and down positions, and positive-stop action to prevent coasting. Mount motor inside roller with vibration isolators to reduce noise transmission.
   3. Screen Mounting: Top edge securely anchored to rigid metal roller and bottom edge formed into a pocket holding a 3/8-inch- (9.5-mm-) diameter metal rod with ends of rod protected by plastic caps.
      a. Roller for motor in roller supported by vibration- and noise-absorbing supports.
   4. Tab Tensioning: Provide units that have a durable low-stretch cord, such as braided polyester, on each side of screen connected to edge of screen by tabs to pull screen flat horizontally. In lieu of tab tensioning, screens may be constructed from vinyl-coated screen cloth that contains horizontal stiffening monofilaments to resist edge curling.

B. Suspended, Electrically Operated Screens without Ceiling Closure: Motor-in-roller units designed and fabricated for suspended mounting, with bottom of case entirely or partially open under screen compartment.
   1. Products: Subject to compliance with requirements provide, Da-Lite Screen Company Tensioned Advantage Deluxe Electrol or comparable product by one of the following:
      a. Motor in Roller:
         1) BEI Audio-Visual Products; Alpine XL.
         2) Draper Inc.; Paragon.
         3) Stewart Filmscreen Corporation; Model A-B.
   2. Provide metal or metal-lined wiring compartment on units with motor in roller.
   3. Screen Case: Made from metal and fire-retardant materials.
   4. Provide screen case constructed to be installed with underside flush with ceiling.
   5. Finish on Exposed Surfaces: Prime painted.

2.2 FRONT-PROJECTION SCREEN MATERIAL

A. Matte-White Viewing Surface: Peak gain not less than 0.9, and gain not less than 0.8 at an angle of 50 degrees from the axis of the screen surface.
   1. Basis of Design: Subject to compliance with requirements provide, Da-Lite Screen Company; Da-Mat, or comparable product by one of the following:
      a. BEI Audio-Visual Products; Matte White.
      b. Bretford, Inc.; Matte White.
      c. Draper Inc.; Fiberglass Matte White.

B. Material: Vinyl-coated, glass-fiber fabric or vinyl sheet.

C. Mildew-Resistance Rating: 0 or 1 when tested according to ASTM G 21.

D. Flame Resistance: Passes NFPA 701.

E. Flame-Spread Index: Not greater than 75 when tested according to ASTM E 84.

F. Seamless Construction: Provide screens, in sizes indicated, without seams.

G. Edge Treatment: Black masking borders.

H. Size of Viewing Surface: 96 inches high by 108 inches wide.

I. Provide extra drop length of dimensions and at locations indicated.
   1. Color: Black.

PART 3 - EXECUTION

3.1 FRONT-PROJECTION SCREEN INSTALLATION

A. Install front-projection screens at locations indicated to comply with screen manufacturer's written instructions.

B. Install front-projection screens with screen cases in position and in relation to adjoining construction indicated. Securely anchor to supporting substrate in a manner that produces a smoothly operating screen with vertical edges plumb and viewing surface flat when screen is lowered.
   1. Install low-voltage controls according to NFPA 70 and complying with manufacturer's written instructions.
      a. Wiring Method: Install wiring in raceway except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use UL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
   2. Test electrically operated units to verify that screen controls, limit switches, closures, and other operating components are in optimum functioning condition.
   3. Test manually operated units to verify that screen-operating components are in optimum functioning condition.

END OF SECTION

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SECTION 11 53 00

MISCELLANEOUS LABORATORY EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. SECTION INCLUDES:
1. Articulating Arm Point Exhaust
2. Biological Safety Cabinets (BSC)
3. Cylinder Restraints
4. Corrals Cylinder Storage
5. Heavy Duty Shelving
6. Modular Wall System

1.2 RELATED DOCUMENTS

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

B. Division 01 – Sustainable Design Requirements.

C. Division 12 – General Requirements for Casework

D. Division 22 - Plumbing Requirements

E. Division 23 – HVAC Requirements

F. Division 26 – Electrical Requirements

1.3 REFERENCES

A. American National Standards Institute (ANSI)
1. ANSI/UL 3101.1 – Electrical Equipment for Laboratory Use: General Requirements.

B. Underwriters Laboratories, Inc. (UL)
1. 1262 - Laboratory Equipment

C. American Society of Testing Materials (ASTM)
1. A167 – Stainless Steel, Alloy 302 or 304.
2. E84 – Burning Characteristics of Building Materials
3. MT1010 – Support Columns

D. NSF International (NSF)
1. Standard #49

1.4 PROJECT CONDITIONS

A. Field Measurements

1. Take field measurements to verify or supplement dimensions indicated. Be responsible for accurate fit of the Work.
2. Verify that all equipment in this section is coordinated to provide a complete working process and system integration.

B. Utilities Verification
1. Utilities and connections may vary between approved manufacturers.
2. All utilities for these items are indicated in mechanical and electrical documents and are referenced in Divisions 15 and 16 / 21 through 28. Any deviations from these utilities must be documented within bid and shop drawing submittals.

1.5 WARRANTY
1. Manufacturer will repair or replace, at no cost to the Owner, any defective components or system, including all labor and material and for a period of (1) one year, unless noted otherwise, from date of operational acceptance by the Owner.
2. Date of operational acceptance shall be after factory check, test and start-up service is complete, the unit is operating in a satisfactory manner, and the equipment has been satisfactorily commissioned by the Owner. The operational acceptance date shall be obtained in writing from the Owner.
3. Owner will perform routine maintenance as described in the Manufacturers Standard Operation and Maintenance manuals during the warranty period. Owner's performance shall in no way invalidate said warranties.

1.6 ACTION SUBMITTALS

A. Shop Drawings
1. Submit shop drawings showing layout and details of fabrication and installation, including utility connections, wiring diagrams, and motor horsepower.
   a. Models indicated in this section to include all standard features listed in latest catalog or website at date of submittal

1.7 CLOSEOUT SUBMITTALS

A. Operations and Maintenance Data
1. Submit operations and maintenance instructions

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Units must conform to the Uniform Plumbing Code and the National Electrical Code.

B. All mechanical and electrical components shall comply with the requirement of Divisions 21 through 28.

2.2 ARTICULATING ARM POINT EXHAUST: (PE): (EQ-120)

A. General
1. To provide flexibility in laboratories for the extraction of airborne contaminants at multiple positions with convenient and simple adjustments.

B. Description and Features
1. Three pivot joints for positioning with tube pipes for a total extension length of 5 feet nominal.
2. Tube pipes manufactured from anodized aluminum and joints with ball bearings from polypropylene.
3. Ceiling mounted units for 3-inch exhaust connection.

4. Ceiling mounted bracket and plate with vertical extension so that bottom of pivot joint connector is at 6 foot, 6 inches above the floor, to provide full service at desktop level.
5. Air-tight damper with control at lowest tube of assembly.
   a. To facilitate cleaning the inside of the suction duct, assemble so that dismantling is easy.
   b. Provide angle nozzle and dome hood for each assembly.

C. Manufactures
1. Nederman Standard Arm FX 75 is the basis of design. Standard part numbers below are from Nederman catalog.
   a. Nozzle / Hood: 70371634
   b. Arm Configuration: 70502134
   c. Bracket: 70371626
   d. Vertical Extension Tube provided by manufacturer.
2. Products of the following manufacturers are acceptable provided they meet the criteria of these specifications:
   a. Enviroflex “Movex” series
   b. As approved by Architect.
3. Exhaust capacity: 150 CFM

2.3 BIOLOGICAL SAFETY CABINETS (BSC): (EQ-060, EQ-061, EQ-062)

A. General
1. Biological safety cabinets shall function as a containment unit that will protect the operator, product, and environment from airborne particulate contaminants. This is accomplished by capturing particulate within replaceable filters installed within the cabinet. The cabinets, countertops, sinks, faucets, gas cocks and other parts listed below will be provided and installed as a package.
2. Certification
   a. NSF International Certification; Standard #49.
      1) Each unit before shipping shall be tested and certified to assure cabinet meets class II requirements. A copy of this test to be provided with the unit.
3. Warranty: 36-months on product and installation.
4. See BSC/LFH schedule following this section for size, location, and type of units

B. Manufacturers
1. The Baker Co.
2. Nuaire
3. Labconco
4. Thermo Fisher
5. As approved by Architect

C. Biosafety Cabinet Type
1. BSC-1: Class II, Type A2 (EQ-060, EQ-061)
   a. Basis of Design Model: SterilGARD E3
      1) Model: SG603A-HE six-foot long units; SG503A-HE five-foot long unit.
   b. Plumbing: Fixtures and service cocks as noted on schedule.
   c. Mechanical:
      1) 70% Recirculated air / 30% Exhausted
      2) Integrated HEPA supply and exhaust filters.
   d. Electrical:
      1) Minimum of two GFI duplex outlets.
      2) NEMA 5-20P, 20-amp plug.
   e. Stand and Work Surface: Stand with telescoping legs that allows work surface to be adjusted between 30” and 38 5/8” nominal above finished floor.

2. BSC-2: Class II, Type B2 (EQ-062)
   a. Basis of Design Model: SterilGARD TX
      1) Model: SG603A TX six-foot long units
   b. Plumbing: Fixtures and service cocks as noted on schedule.
   c. Mechanical:
      1) 100% Exhausted
   d. Electrical:
      1) Minimum of two GFI duplex outlets.
      2) NEMA 5-20P, 20-amp plug.
   e. Stand and Work Surface: Stand with telescoping legs that allows work surface to be adjusted between 30” and 38 5/8” nominal above finished floor.
   f. DC motors for energy conservation

D. Description
1. All stainless steel interior construction
2. Sliding counterbalanced vertical view screen.
3. Adjustable, epoxy coated steel base stand where noted on elevations.
4. Front accessible supply and exhaust filters. Double HEPA supply filters above and below the work area to prevent motor/blower contamination; 99.99% minimum efficiency when filtering particles of 0.3 micrometers.
5. Microprocessor control system with audible/visible alarm to monitor airflow and sash set point.
6. Color: To match Thermo Scientific PW Petal White 1362.
7. Idle mode feature
8. Bio Safety Cabinets located in room L044 are part of Alternate No. A-~~4~~3

E. Plumbing
1. Petcocks for air and vacuum service connections at right side with connections at top for smaller required footprint.
2. Air and Vacuum Fixtures
   a. Provide stainless steel floating needle and removable stainless steel seat for air and vacuum valves. Action of valve: slow compression for fine control under pressures up to 690KPa (100 PSI).
3. Flammable Gas Fixtures
   a. Provide a stainless steel ball valve at flammable gas valves at pressures up to 1/2 PSI. Provide American Gas Association certification.
4. Stainless steel ball valve for drainage of the drain pan.
5. Include piping from service connection at top or rear of hood to valves.

F. Mechanical
1. Include piping from service connection at top or rear of hood to valves.
2. Services
   a. Air: 1/2” NPT.
   b. Vacuum: 1/2” NPT.
   c. Gas: 1/2" NPT.

G. Electrical
1. Average fluorescent illumination of the work area: minimum of 100 foot-candles.
2. GFI duplex outlet with covers and circuit breakers in each work area side wall; additional outlets as indicated on schedule.
3. 120 Volts, 1 Phase, 60 Hz, 20 Amp dedicated circuit, hard-wired connection.
4. UL listed for electrical, fire, and personal safety.
5. Ultra violet light

H. Service Fixtures
1. General
a. Furnish mechanical and electrical fixtures to be mounted in or in conjunction with biosafety cabinets.
b. Provide gas, air, and vacuum fixtures as indicated on the biosafety cabinet schedule in the AQ drawing series.
c. Identify mechanical services with full view colored index buttons in accordance with U.S. Standard Color Code.
d. Provide factory assembled shanks for deck mounting or panel mounting.
e. Material: Colored epoxy coated brass by Water Saver Faucet Co. or equivalent models as manufactured by Chicago Faucet Co. or T & S Brass and Bronze Works. Equip faucets with laboratory serrated hose ends or aerators as indicated. Color: See Section 12 31 00, "General Requirements for Casework and Fume Hoods" for fixtures selection.
f. Fixture surfaces exposed on interior of hood coated with an acid-and-solvent-resistant finish baked on to minimum dry film thickness of 50 micrometers (2 mils).
2. Air and Vacuum Fixtures
a. Provide stainless steel floating needle and removable stainless steel seat for air and vacuum valves. Action of valve: slow compression for fine control under pressures up to 690KPa (100 PSI).
3. Flammable Gas Fixtures
a. Provide a stainless steel ball valve at flammable gas valves at pressures up to 1/2 PSI. Provide American Gas Association certification.
4. Electrical Fixtures
a. Receptacles for casework are specified to be provided in Division 26.
b. Receptacles for biosafety cabinets: 20-ampere, 125-volt, 2-pole, 3-wire, GFI, NEMA 5-20R, GFI.
c. UL listed and furnished with grounding screws, mounting shanks, and locknuts.
d. Faceplates: brushed stainless steel with configurations to mate with pedestals, wiring devices and telecommunication devices as indicated.

2.4 CYLINDER RESTRAINTS (CR): (EQ-121)

A. General
1. Device designed to mount and secure gas cylinders to walls, work benches, and floors.
2. Gas Cylinder restraints shall be cast aluminum body with a nylon strap with adjustable buckle and safety chain.
3. Quantities and configuration as indicated on drawings

B. Manufacturer
1. Matheson Gas Products is the basis of design
a. Wall Mount: Model 510-W
b. Floor Rack (2 cylinder): Safe-T-Rack Model 6531
c. Floor Rack (6 cylinder): Safe-T-Rack Model 6533
2. Products meeting these requirements from manufacturers listed below are also acceptable:
a. Troemmer Henry, Inc.
b. Union Carbide Industrial Gases, Linde Div.
c. As approved by Architect

2.5 CORRAL CYLINDER STORAGE (CCS): (EQ-122)

A. General

1. Steel cylinder restraint unit, designed to restrain six gas cylinders 10” – 12” diameter or nitrogen tanks up to 28” diameter.

B. Manufacturer
1. Strand, First Safety Corp.
2. Work Safe Technologies.
3. Specialty Gas Equipment.

C. Description
1. All steel construction with lab-approved exterior-grade urethane powder-coat finish.
   a. 1” x 2”-thick steel tubing frames.
   b. Adjustable back frame allows side panels to be set to accommodate cylinders of various widths.
   c. Side panels anchor to concrete floor with welded “L” brackets.
   d. Seismic Tank Corral with back frame anchors to concrete floor or wall.
   e. Hardware is galvanized for corrosion resistance.
   f. Available with steel chain or stainless-steel cable restraints.

2.6 WIRE STORAGE AND SHELVING SYSTEM ASSEMBLY: (EQ-123A, EQ-123B, EQ-123C, EQ-123D)

A. General
1. Wire storage and shelving system

B. Manufacturer
1. InterMetro Industries Corporation, “Super Adjustable and Super Erecta Wire Shelving”, or as approved.

C. Description and Features
1. Sizes as indicated on drawings and sheet AQ0.1
2. All stainless steel construction.
3. 4 stationary posts per assembly at 84 inches nominal high including leveling feet and caps.
4. Wire shelves adjustable in one inch increments with plastic sleeves and wedges included with each shelf.
5. Provide 7 shelves per unit including top shelf.
6. Quantities and assembly widths and depths as indicated on drawings.

2.7 MODULAR WALL SYSTEM: (EQ-124)

A. Stainless steel demising wall located in Glasswash room.

B. Manufacturer
1. Steris Corp. Model “AMSCO”
2. Getting USA, Inc.
3. Primus Sterilizer Co. Inc.

C. Description and Features
   a. Modular wall system for concealing body, piping, wiring, and other equipment appurtenances; for confining excessive equipment heat and vapor to enclosure area; and for providing a finished appearance and easy clean-ability.
   b. Height of modular wall system to underside of interstitial floor above, enclose for vapor, etc.
   c. Each modular wall shall be furnished from standardized components. Panels shall be box-shaped, finished on the face side and insulated on the reverse with moisture-resistant, sound deadening material bonded to the metal surface.
   d. Major components to include:

1) Vertical Panels: to cover the areas between pieces of equipment and supported by vertical column supports. Include shims for leveling of vertical panels to accommodate uneven floors.
2) Column Supports: to provide rigidity for vertical panels with welded-angle and tubular-steel construction and a painted-steel finish. Anchor supports to building structural ceiling and bolt to vertical panels.
3) Horizontal Panels: to enclose openings remaining in the wall after equipment has been set in place. Panels shall be furnished with a louver to permit venting of equipment heat and vapor to the rear of modular wall.
4) Trim Angles: to conceal clearance openings between modular wall and adjacent building walls and ceiling.
5) Hinged Access Doors: double-wall pan constructed with sound-deadening insulation between the walls.
6) Horizontal Support Angles: to provide a surface to which ceiling trim angles can be connected and to provide additional support for the entire wall.
7) Corner Post: to be used at the juncture of two faces of modular wall to provide stability and a finished appearance.
8) All components to be stainless steel except for insulation and support columns.
9) Exposed panels shall be stainless steel. Concealed components shall be enameled or galvanized steel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate delivery of all equipment with all building work and scheduling for final placement

B. Install the Work completely. Include final connection to mechanical and electrical services and all connections between components of each system. Install in accordance with manufacturer's instructions and approved Shop Drawings and under the supervision of the manufacturer's representative.

C. Touch up damaged finishes equal to original condition as approved. Make final adjustments required for proper operation as determined by the Architect.

3.2 DEMONSTRATION

A. The manufacturer shall provide four copies of operation manual describing equipment operating and routine maintenance service procedures. Instruct the Owner's designated representatives in these procedures during the startup and test period.

B. Training
1. Provide training for the following equipment:
   a. BioSafety Cabinets
2. Training shall be a 1-day (6 hours).
3. Training shall be conducted by a factory authorized service representative when mutually agreed to with the Owner.

END OF SECTION

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SECTION 11 71 00

STERILIZING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Medium Steam Sterilizer

1.2 RELATED DOCUMENTS

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

B. Division 01 – Sustainable Design Requirements.

C. Division 22 – Plumbing Requirements

D. Division 23 – HVAC Requirements

E. Division 26 – Electrical Requirements

F. Related Work Specified Elsewhere
1. Final connection to services are specified in Divisions 21 through 28 and indicated on the Mechanical, Electrical, and Plumbing drawings.
2. Related Section, 11 23 00 – Washing and Drying Equipment

1.3 REFERENCES

A. American National Standards Institute (ANSI) / Association for the Advancement of Medical Instrumentation (AAMI)
1. ST8 – Hospital Steam Sterilizers

B. American Society of Mechanical Engineers (ASME)
1. ASME – Boiler and Pressure Vessel Code.
a. Section VIII – Pressure Vessels, Division 1.
2. ASME – High Pressure Systems
3. ASME B31.3 – Process Piping

C. Underwriters Laboratories, Inc. (UL)
1. 544 - Medical and Dental Equipment

D. Federal Specifications (FED SPEC)
1. GG-S-1340 – Sterilizer, Surgical Instrument and Supply Gravity Air Removal, Non-portable (Heat and Moisture Stable).
2. GG-S-1343 – Sterilizer, Surgical Instrument and Supply Mechanical Air Removal, Non-portable (Heat and Moisture Stable).

E. American Society of Testing Materials (ASTM)

1. ASTM A 167 – Stainless and Heat Resisting Chromium Nickel Steel Plate, Sheet, and Strip.
2. ASTM A 240 – Heat Resisting Chromium and Chromium Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessel.
3. ASTM A 263 – Corrosion Resisting Chromium Steel Clad Plate, Sheet and Strip.
4. ASTM A 264 – Stainless Chromium Nickel Steel Clad Plate, Sheet and Strip.
5. ASTM A 265 – Nickel and Nickel Base Alloy Clad Steel Plate.
6. ASTM A 269 - Seamless and Welded Austenitic Stainless Steel Tubing for General Services.
7. ASTM A 312 – Seamless and Welded Austenitic Stainless Steel Pipe.
8. ASTM A 366 – Steel, Sheet, Carbon, Cold-Rolled Sheet, Commercial Quality.
9. ASTM B 39 – Nickel.
10. ASTM B 42 – Seamless Copper Pipe, Standard Sizes.
11. ASTM B 43 – Seamless Red Brass Pipe, Standard Sizes.
12. ASTM B 88 – Seamless Copper Water Tube.
13. ASTM B 127 – Nickel Copper Alloy, Plate, Sheet and Strip.
14. ASTM B 135 – Seamless Brass Tube.
15. ASTM B 166 – Nickel Chromium Iron Alloys, Rod, Bar and Wire.
16. ASTM B 167 – Nickel Chromium Iron Alloys, Seamless Pipe and Tube.
17. ASTM B 339 – Pig Tin.
18. ASTM B 348 – Titanium and Titanium Alloy Bars and Billets

1.4 PROJECT CONDITIONS

A. Field Measurements
1. Take field measurements to verify or supplement dimensions indicated. Be responsible for accurate fit of the Work.
2. Verify that all equipment in this section is coordinated to provide a complete working process and system integration

B. Utilities Verification
1. Utilities and connections may vary between approved manufacturers.
2. All utilities for these items are indicated in mechanical and electrical documents and are referenced in Divisions 15 and 16 / 21 through 28. Any deviations from these utilities must be documented within bid and shop drawing submittals.

1.5 WARRANTY

1. Manufacturer will repair or replace, at no cost to the Owner, any defective components or system, including all labor and material and for a period of (1) one year, unless noted otherwise, from date of operational acceptance by the Owner.
2. Date of operational acceptance shall be after factory check, test and start-up service is complete, the unit is operating in a satisfactory manner, and the equipment has been satisfactorily commissioned by the Owner. The operational acceptance date shall be obtained in writing from the Owner.
3. Owner will perform routine maintenance as described in the Manufacturers Standard Operation and Maintenance manuals during the warranty period. Owner's performance shall in no way invalidate said warranties.
4. Special Warranty
   a. Warrant pressure vessels for steam sterilizers against structural failure for 15 years from the date of initial operation. Include all parts and labor

1.6 ACTION SUBMITTALS

A. Shop Drawings
1. Submit shop drawings showing layout and details of fabrication and installation, including utility connections, wiring diagrams, and motor horsepower.

a. Models indicated in this section to include all standard features listed in latest catalog or website at date of submittal
b. Submit form for pressure vessels, specified under "General Requirements for Steam Sterilizers".

1.7 CLOSEOUT SUBMITTALS

A. Operations and Maintenance Data
1. Submit operations and maintenance instructions

1.8 GENERAL REQUIREMENTS FOR STEAM STERILIZERS

A. Standards
1. The design, construction, materials and testing shall meet the requirements of the ASME Boiler and Pressure Vessel Code, ETL Testing Laboratory listed to UL 544, Uniform Plumbing Code, and any other local building codes.
2. All electrical and mechanical components shall comply with the requirements of Divisions 21 through 28.

B. Sterilizer Function
1. Unit shall be a steam jacketed sterilizer suitable for the sterilization of heat- and moisture-stable instruments, supplies and utensils utilizing steam saturation as a sterilizing agent.
2. Chamber evacuation shall be either vacuum pump or a vacuum system utilizing a condenser and water ejector.

C. Controls
1. Microprocessor controls shall be provided for all sterilizers. The control unit shall consist of a selectively programmable microcomputer that programs, monitors and controls system operations and functions. It shall be possible to energize the entire system by a single switch. Control unit shall stop, reset and start cycle(s) over if during sterilizing phase chamber temperature falls two degrees below set value or if electric power to the unit fails. Control unit shall have provision to allow connection of sterilizer's computer bus to a remote computer. Automatic controls shall include the following:
a. Status indicator of each cycle phase. Indicator shall visually alert operator if door is un-locked and visually and/or audibly alert if sterilizer does not reach set temperatures or drops below set temperature during sterilizing phase.
b. Digital display with a minimum of 2 lines of 20 characters denoting sterilizer functions, sterilizing time(s) and temperature(s).
c. Programmable cycle selector actuating each cycle individually. Selected cycle shall be visually displayed.
d. Programmable cycle times with cycle times locked once cycle has been actuated.
e. Cycle monitor device, non-resetable, to count each cycle.
f. Main power and control switch to energize and de-energize until.
g. Reset / abort switch to stop cycle.
h. Battery back-up to hold cycle parameters for a minimum of 60 seconds in event of power failure.
i. 24 column alphanumeric thermal printer able to record data at the beginning and end of each cycle, all transition points, print intervals during the exposure phase and alarm parameter(s) report.

D. Cycles
1. Four factory default cycles for pre vacuum, gravity and liquid functions.
2. AU4 Cycle Temperature Ranges:
a. Pre-vacuum: 110-135 degrees C (212-275 degrees F)

b. Gravity: 110-135 degrees C (212-275 degrees F)
c. Liquid: 104-135 degrees C (230-275 degrees F).

3. AU1 Cycle Temperature Ranges:
   a. Pre-vacuum: 110-135 degrees C (230-275 degrees F).
   b. Gravity: 110-135 degrees C (230-275 degrees F).
   c. Liquid: 110-135 degrees C (230-275 degrees F).
   d. Effluent: 121-135 degrees C (250-275 degrees F)
4. AU8 Cycle Temperature Ranges:
   a. Pre-vacuum: 121-137 degrees C (250-279 degrees F)
   b. Gravity: 121-137 degrees C (250-279 degrees F)
   c. Liquid: 121-137 degrees C (250-279 degrees F)
5. Each cycle time shall include the following parameters:
   a. Time and date.
   b. Date format.
   c. Time units.
   d. Overtemperature.
   e. Undertemperature.
   f. Sterilize time
   g. Sterilize temperature.
   h. Dry time values.
   i. Phase alarms.
   j. Sterilize temperature overdrive.
   k. Purge time.
   l. Chamber pressure points.
   m. Print interval.
   n. Number of vacuum pulses.
   o. Pressure & vacuum pulse points.
   p. Vacuum dry point.
6. Each cycle shall be provided with the following safeguards:
   a. Cycle cannot begin unless door is closed and locked pressure tight.
   b. Control shall reject incorrect cycle parameters

E. Alarms
1. The following minimum cycle alarms shall be provided:
   a. Vacuum system failure.
   b. Steam table deviation.
   c. Overextended sterilization time
   d. Vessel flood.
   e. Chamber drain probe failure.

F. Printer
1. Control system is to provide selection of printer output and display window information in English, French or Spanish. Also to provide selective access codes for setting cycles and cycle values to prevent unauthorized changes and use of cycles, adjustment of cycle-status printout intervals. Temperature display and printout units in either degrees F or degrees C, pressure/vacuum display in psig/in Hg or Bars, and either standard AM/PM or Military format. In the laboratory mode of operation, sterilize temperature overdrive, over-temperature point, under-temperature point and chamber pressure points can be set by the operator.
2. In the control column, mount 32-column alphanumeric thermal printer and provide duplicate print switch to furnish a duplicate printout of entire cycle data (when unit is not in cycle) or of current cycle status (during a cycle). Furnish printout with date, cycle count, daily cycle number, starting time of each cycle, sterilize temperature selected, sterilize and dry time selected, key transition points in the

cycle, and any deviations which may jeopardize sterilization process. Design printer to use 2-1/4" single-ply paper; include motorized take-up spool for automatic storage of an entire roll of paper.

G. Pressure gauges shall be provided to display chamber and jacket pressures.

H. The system shall provide automatic condensing of chamber steam and disposal of condensate to waste. Condensate shall be cooled to 60 degrees C (140 degrees F) before discharge to drain.

I. Drain Discharge Cool Down System: Cold water (Chilled water preferred) shall be part of water conservation system to automatically cool the drain discharge temperature below 140°F before entering the building sanitary waste drain. Construct drain of stainless steel.

J. Pressure gauges shall be provided to display chamber and jacket pressures.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Units must conform to the Uniform Plumbing Code and the National Electrical Code.

B. All mechanical and electrical components shall comply with the requirement of Divisions 21 through 28.

2.2 MANUFACTURER

A. Basis-of-Design: Getinge 633LS

B. Products of the following manufacturers are acceptable provided they meet the criteria of these specifications:
1. Steris Corporation
2. Primus Sterilizer Co., Inc.
3. Tuttnauer.

C. The Contract Sum shall include costs related to:
1. Modifications, recommended by the manufacturer for proper installation and performance of products, to intended building construction and utilities.
2. Coordination required to perform the modifications.

D. MEDIUM STEAM STERILIZERS (EQ-002)
1. Configuration and Features
a. Pre-vacuum/Gravity type.
b. Minimum chamber size: 26"W x 26"H x 39"D.
c. Enclosed cabinet model, freestanding – no recess.
d. Single, powered sliding door.
e. Nominal overall dimensions: 53"W x 55"D x 78"H.
f. Touch screen control.
g. Single power operated vertical sliding door with foot pedal actuator.
h. One (1) loading car, one (1) transfer carriage, one (1) loading rack, two (2) shelves, one (1) intermediate shelf.
i. Integral steam generator, 480V 3ph
j. Water saver package
2. Utility Requirements (Design Model)
a. Reagent Grade Water – 1" NPT, 20-50 psig dynamic, 130 gal/hr. flow rate, peak flow 15 gal/min.

b. Steam – 1” NPT, 97% to 100% vapor quality, 50-80 psig dynamic, consumption 148 lbs/hr, peak flow 255 lbs/hr.
c. Drain – 2” ODT drain terminal
d. Air – ¼” NPT, 70-100 PSIG dynamic, 1 SCFM
e. Controls Electrical – 120V, 60Hz., 1 PH, 2A circuit.
f. Vacuum Pump Electrical – 208 V, 60Hz., 3 PH, 6A circuit.
g. Relief valve vent – 3/4” NPT

E. MODULAR WALL SYSTEM (EQ-204)
1. Description and Features
a. Modular wall system for concealing body, piping, wiring, and other equipment appurtenances; for confining excessive equipment heat and vapor to enclosure area; and for providing a finished appearance and easy clean-ability.
b. Height of modular wall system to underside of interstitial floor above, enclose for vapor, etc.
c. Each modular wall shall be furnished from standardized components. Panels shall be box-shaped, finished on the face side and insulated on the reverse with moisture-resistant, sound deadening material bonded to the metal surface.
d. Major components to include:
1) Vertical Panels: to cover the areas between pieces of equipment and supported by vertical column supports. Include shims for leveling of vertical panels to accommodate uneven floors.
2) Column Supports: to provide rigidity for vertical panels with welded-angle and tubular-steel construction and a painted-steel finish. Anchor supports to building structural ceiling and bolt to vertical panels.
3) Horizontal Panels: to enclose openings remaining in the wall after equipment has been set in place. Panels shall be furnished with a louver to permit venting of equipment heat and vapor to the rear of modular wall.
4) Trim Angles: to conceal clearance openings between modular wall and adjacent building walls and ceiling.
5) Hinged Access Doors: double-wall pan constructed with sound-deadening insulation between the walls.
6) Horizontal Support Angles: to provide a surface to which ceiling trim angles can be connected and to provide additional support for the entire wall.
7) Corner Post: to be used at the juncture of two faces of modular wall to provide stability and a finished appearance.
8) All components to be stainless steel except for insulation and support columns.
9) Exposed panels shall be stainless steel. Concealed components shall be enameled or galvanized steel.
e. Access/Service door provided as part of wall system

F. BUILDING UTILITIES AVAILABLE
1. All utilities for these units are indicated in Mechanical, Electrical, and Plumbing documents and are referenced in Divisions 21 through 28. Any deviations from these utilities must be documented within bid and shop drawing submittals.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the Work completely, and in accordance with manufacturer's instructions and approved Shop Drawings and under the supervision of the manufacturer's representative.

B. Touch up damaged finishes equal to original condition as approved. Make final adjustments required for proper operation as determined by the Architect.

C. Test all unit functions. Provide a dated report to Owner's representative certifying that the unit functions properly.

3.2 DEMONSTRATION

A. The manufacturer shall provide four copies of operation manual describing equipment operating and routine maintenance service procedures. Instruct the Owner's designated representatives in these procedures during the startup and test period.

B. Training
   1. Training shall be a 1-day (6 hours), 2 sessions per model minimum.
   2. Training shall be conducted by a factory authorized service representative when mutually agreed to with the Owner.

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SECTION 12 24 13

ROLLER WINDOW SHADES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Manually operated roller shades with single rollers.
2. Motor-operated roller shades.

B. Related sections:
1. Division 09 section “Gypsum Board”, for installation in gypsum wall assemblies
2. Division 26 section “Wiring and Cabling” for wiring associated with the activation of the motorized components of the assembly.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include styles, material descriptions, construction details, dimensions of individual components and profiles, features, finishes, and operating instructions for roller shades.

B. Shop Drawings: Show fabrication and installation details for roller shades, including shadeband materials, their orientation to rollers, and their seam and batten locations.
1. Motor-Operated Shades: Include details of installation and diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified, 10 inches long.

D. Samples for Initial Selection: For each type and color of shadeband material.
1. Include Samples of accessories involving color selection.

E. Samples for Verification: For each type of roller shade.
1. Shadeband Material: Not less than 10 inches square. Mark inside face of material if applicable.
2. Roller Shade: Full-size operating unit, not less than 16 inches wide by 36 inches long for each type of roller shade indicated.
3. Installation Accessories: Full-size unit, not less than 10 inches long.

F. Roller-Shade Schedule: Use same designations indicated on Drawings.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Certificates: For each type of shadeband material, signed by product manufacturer.

C. Product Test Reports: For each type of shadeband material, for tests performed by manufacturer and witnessed by a qualified testing agency.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For roller shades to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Roller Shades: Full-size units equal to 5 percent of quantity installed for each size, color, and shadeband material indicated, but no fewer than two units.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver roller shades in factory packages, marked with manufacturer, product name, and location of installation using same designations indicated on Drawings.

1.9 FIELD CONDITIONS

A. Environmental Limitations: Do not install roller shades until construction and finish work in spaces, including painting, is complete and dry and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

B. Field Measurements: Where roller shades are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication and indicate measurements on Shop Drawings. Allow clearances for operating hardware of operable glazed units through entire operating range. Notify Architect of installation conditions that vary from Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: Subject to compliance with requirements provide Mechoshade Systems, Inc., or comparable product-by one of the following:
   1. Draper Inc.
   2. Hunter Douglas Contract.
   3. Lutron Electronics Co., Inc.

B. Source Limitations: Obtain roller shades from single source from single manufacturer.

2.2 SHADES WITH SINGLE ROLLERS- GENERAL

A. Rollers: Corrosion-resistant steel or extruded-aluminum tubes of diameters and wall thicknesses required to accommodate operating mechanisms and weights and widths of shadebands indicated without deflection. Provide with permanently lubricated drive-end assemblies and idle-end assemblies designed to facilitate removal of shadebands for service.
   1. Roller Drive-End Location: As indicated on Drawings.
   2. Direction of Shadeband Roll: Regular, from back of roller.
   3. Shadeband-to-Roller Attachment: Manufacturer's standard method.

B. Mounting Hardware: Brackets or endcaps, corrosion resistant and compatible with roller assembly, operating mechanism, installation accessories, and mounting location and conditions indicated.

C. Shadebands:
1. Shadeband Material: Light-filtering fabric.
2. Shadeband Bottom (Hem) Bar: Steel or extruded aluminum.
   a. Type: Enclosed in sealed pocket of shadeband material.
   b. Color and Finish: As selected by Architect/Engineer from manufacturer's full range.

2.3 MANUALLY OPERATED SHADES WITH SINGLE ROLLERS

A. Chain-and-Clutch Operating Mechanisms: With continuous-loop bead chain and clutch that stops shade movement when bead chain is released; permanently adjusted and lubricated.
1. Bead Chains: Manufacturer's standard.
   a. Loop Length: Full length of roller shade.
   b. Limit Stops: Provide upper and lower ball stops.
   c. Chain-Retainer Type: Chain tensioner, jamb mounted.
2. Spring Lift-Assist Mechanisms: Manufacturer's standard for balancing roller-shade weight and lifting heavy roller shades.
   a. Provide for shadebands that weigh more than 10 lb or for shades as recommended by manufacturer, whichever criteria are more stringent.

B. Installation Accessories:
1. Front Fascia: Aluminum extrusion that conceals front and underside of roller and operating mechanism and attaches to roller endcaps without exposed fasteners.
   a. Shape: L-shaped.
   b. Height: Manufacturer's standard height required to conceal roller and shadeband when shade is fully open, but not less than 4 inches.
2. Recessed Shade Pocket: Rectangular, extruded-aluminum enclosure designed for recessed ceiling installation; with front, top, and back formed as one piece, end plates, and removable bottom closure panel.
   a. Height: Manufacturer's standard height required to enclose roller and shadeband when shade is fully open, but not less than 5 inches.
   b. Provide pocket with lip at lower edge to support acoustical ceiling panel.
3. Installation Accessories Color and Finish: As selected from manufacturers’ full range.

2.4 MOTOR-OPERATED, SINGLE-ROLLER SHADES

A. Motorized Operating System: Provide factory-assembled, shade-operator system of size and capacity and with features, characteristics, and accessories suitable for conditions indicated, complete with electric motor and factory-prewired motor controls, power disconnect switch, enclosures protecting controls and operating parts, and accessories required for reliable operation without malfunction. Include wiring from motor controls to motors. Coordinate operator wiring requirements and electrical characteristics with building electrical system.
1. Electrical Components: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Electric Motor: Manufacturer's standard tubular, enclosed in roller.
   a. Electrical Characteristics: Single phase, 110 V, 60 Hz.
3. Remote Control: Electric controls with NEMA ICS 6, Type 1 enclosure for recessed or flush mounting. Provide the following for remote-control activation of shades:
   a. Individual/Group Control Station: Maintained-contact, three-position, rocker-style, wall-switch-operated control station with open, close, and center off functions for individual and group control.
   b. Microprocessor Control: Electronic programmable means for setting, changing, and adjusting control features; isolated from voltage spikes and surges.

c. Color: As selected by Architect/Engineer from manufacturer's full range.

4. Limit Switches: Adjustable switches interlocked with motor controls and set to stop shades automatically at fully raised and fully lowered positions.
5. Operating Features:
   a. Group switching with integrated switch control; single faceplate for multiple switch cutouts.
   b. Capable of interface with audiovisual control system.

B. Installation Accessories:
1. Recessed Shade Pocket: Rectangular, extruded-aluminum enclosure designed for recessed ceiling installation; with front, top, and back formed as one piece, end plates, and removable bottom closure panel.
   a. Height: Manufacturer's standard height required to enclose roller and shadeband when shade is fully open.
2. Closure Panel and Wall Clip: Removable aluminum panel designed for installation at bottom of site-constructed ceiling recess or pocket and for snap-in attachment to wall clip without fasteners.
   a. Closure-Panel Width: As indicated on Drawings.
3. Installation Accessories Color and Finish: As selected from manufacturer's full range.

2.5 SHADEBAND MATERIALS

A. Shadeband Material Flame-Resistance Rating: Comply with NFPA 701. Testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

B. Light-Filtering Fabric (Manual Operation): PVC-Free, Woven fabric, stain and fade resistant.
1. Roll Width: 72 inches
2. Orientation on Shadeband: Up the bolt.
3. Openness Factor: 15 percent.
4. Fabric: Mechoshade; Thermo Veil Dense Basket Weave series 2100
5. Color: Mechoshade 2120 Shadow grey.

C. Light-Filtering Fabric (Electrical Operation): PVC-free, woven fabric, stain and fade resistant.
1. Source: Roller-shade manufacturer.
2. Type: Interior-translucent.
3. Roll Width: 8’-3” and 13’-00” located as indicated on the Drawings.
4. Orientation on Shadeband: Up the bolt.
5. Openness Factor: 3 percent.
6. Fabric: Mechoshade; Ecoveil 1550 series
7. Color: 1520 Shadow Grey.
8. Acceptable Products and Manufacturers:
   a. Greenscreen ECO, Charcoal by Nysan Solar Control, Inc.
   b. Vela, GU-0030, Charcoal, by Mermet Industries.

2.6 ROLLER-SHADE FABRICATION

A. Product Safety Standard: Fabricate roller shades to comply with WCMA A 100.1, including requirements for flexible, chain-loop devices; lead content of components; and warning labels.

B. Unit Sizes: Fabricate units in sizes to fill window and other openings as follows, measured at 74 deg F:
   1. Between (Inside) Jamb Installation: Width equal to jamb-to-jamb dimension of opening in which shade is installed less 1/4 inch per side or 1/2-inch total, plus or minus 1/8 inch. Length equal to head-to-sill or -floor dimension of opening in which shade is installed less 1/4 inch, plus or minus 1/8 inch.
   2. Outside of Jamb Installation: Width and length as indicated, with terminations between shades of end-to-end installations at centerlines of mullion or other defined vertical separations between openings.

C. Shadeband Fabrication: Fabricate shadebands without battens or seams to extent possible except as follows:
   1. Vertical Shades: Where width-to-length ratio of shadeband is equal to or greater than 1:4, provide battens and seams at uniform spacings along shadeband length to ensure shadeband tracking and alignment through its full range of movement without distortion of the material.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

3.2 ROLLER-SHADE INSTALLATION

A. Install roller shades level, plumb, and aligned with adjacent units according to manufacturer's written instructions.
   1. Opaque Shadebands: Located so shadeband is not closer than 2 inches to interior face of glass. Allow clearances for window operation hardware.

3.3 ADJUSTING

A. Adjust and balance roller shades to operate smoothly, easily, safely, and free from binding or malfunction throughout entire operational range.

3.4 CLEANING AND PROTECTION

A. Clean roller-shade surfaces after installation, according to manufacturer's written instructions.

B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that roller shades are without damage or deterioration at time of Substantial Completion.

C. Replace damaged roller shades that cannot be repaired, in a manner approved by Architect, before time of Substantial Completion.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Using Agent's maintenance personnel to adjust, operate, and maintain motor-operated roller shades.

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SECTION 12 31 00

GENERAL REQUIREMENTS FOR CASEWORK AND FUME HOODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Section 12 31 01 – High Performance Fume Hoods

C. Section 12 31 03 – Flexible Casework Systems

D. Section 12 31 04 – Metal Laboratory Casework

E. Related Work Specified Elsewhere
1. Final connection to services are specified in Divisions 21 through 28 and indicated on the Mechanical, Electrical, and Plumbing drawings.

1.2 REFERENCES

A. American National Standards Institute (ANSI)
1. A208.1 – Particleboard
2. A117.1 – Accessible and Usable Buildings and Facilities

B. American Hardboard Association (AHA)
1. A135.4 – Basic Hardboard

C. National Electrical Manufacturers Association (NEMA)
1. LD 3 – High-Pressure Decorative Laminates

D. American Society of Testing Materials (ASTM)
1. ASTM A 167 – Stainless and Heat Resisting Chromium Nickel Steel Plate, Sheet, and Strip.
2. ASTM A 366/ A 366M – Steel, Sheet, Carbon, Cold-Rolled Sheet, Commercial Quality.
3. ASTM B 221 – Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes [Metric]
4. ASTM B 584 – Copper Alloy Sand Castings for General Applications.
5. ASTM C 1036 – Flat Glass
6. ASTM D 570 – Test Method for Water Absorption of Plastics.
7. ASTM D 635 – Test Method for Rate of Burning and/or Extent of Time of Burning of Self-Supporting Plastics in a Horizontal Position.
8. ASTM D 695 – Test Method for Compressive Properties of Rigid Plastics.
9. ASTM D 785 – Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials.
10. ASTM D 790 – Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

E. U.S. Department of Commerce, National Institute of Standards and Technology
1. PS 1 – Construction and Industrial Plywood.
2. PS 51 – Hardwood and Decorative Plywood.

F. Scientific Equipment and Furniture Association (SEFA)
1. 2008 SEFA Desk Reference, Third Edition.

1.3 PROJECT CONDITIONS

A. Field Measurements
1. Take field measurements to verify or supplement dimensions indicated. Be responsible for accurate fit of the Work.
2. Verify that all equipment in this section is coordinated to provide a complete working process and system integration

B. Utilities Verification
1. Utilities and connections may vary between approved manufacturers.
2. All utilities for these items are indicated in mechanical and electrical documents and are referenced in Divisions 15 and 16 / 21 through 28. Any deviations from these utilities must be documented within bid and shop drawing submittals.

1.4 ACTION SUBMITTALS

A. Submittal Compliance Form
1. Submit a statement of compliance for the following:
a. Performance requirements
b. Polyvinylchloride
c. Molded resin
d. Materials specified to have a maximum fire hazard classification.

B. Shop Drawings
1. Indicate the following:
a. Location of assemblies
b. Details of construction
c. Details of connections between units and to adjacent work
d. Location and size of holes and cutouts
e. Dimensional locations for rough-in of mechanical and electrical services.
f. Molded epoxy resin tops jointing pattern.

C. Samples
1. Submit Samples which conform to specified requirements, including construction and finishes. Samples will be retained for comparison with Work fabricated and will be returned upon completion of the Contract.
2. Submit the following Samples for approval:
a. One full size combination drawer and cupboard base cabinet with all hardware.
b. One of each top material of size sufficient for testing
c. One of each mechanical service fixtures.

1.5 CLOSEOUT SUBMITTALS

A. Operations and Maintenance Data
1. Furnish operations and maintenance instructions for related equipment and fume hoods.

B. Receipts
1. Furnish receipts for keys and other loose items.

1.6 COORDINATION OF MECHANICAL FIXTURES

A. Furnish faucets and valves for casework and metal fume hoods by the same manufacturer to unify replacement parts. Coordinate the furnishing of such fixtures under each Section of casework.

B. If the bid is based on fixtures by different manufacturers, submit a separate price for the mechanical fixtures for each type of casework prior to award of Contract.

C. No adjustment in Contract price will be approved after award of Contract for coordination of mechanical fixtures in casework.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Subject to requirements, provide one of the following systems of support framing:
1. Bedcolab Ltd.
2. Jamestown Metal Products
3. Kewaunee Scientific Equipment Corp.
4. Mott Manufacturing Limited
5. ALC / Thermo Fisher Scientific (Hamilton)

2.2 GENERAL

A. Provide casework, including cabinets and countertops, which is the product of one of the manufacturers specified for each type of casework.

B. Provide materials, construction and finishes in accordance with the specifications listed below.

C. Metal Gauges
1. Construct metal cabinets of sheet steel with minimum thickness in mm (U.S. standard gauge) as follows:

Corner gussets for leveling bolts and apron corner braces wall rail systems	2.7 mm (12 gage)
Drawer support channels	1.9 mm (14 gage)
Hinge reinforcement	1.9 mm (14 gage)
Horizontal rails, and reinforcing gussets	1.5 mm (16 gage)
Aprons	1.5 mm (16 gage)
Support struts	1.5 mm (16 gage)
Cabinet tops, ends, bottom, backs, vertical posts, shelves, glazed doors	1.2 mm (18 gage)
Door panels, scribing strips, filler panels, enclosures, drawer fronts and bodies, closure panels, overhead service carriers	0.9 mm (20 gage)

2.3 MATERIALS

A. Molded Resin
1. Modified epoxy resin as manufactured by Durcon Co., Inc.; Epoxyn Products; Kewaunee Scientific Equipment Corp.; Laboratory Tops, Inc.; or as approved, uniform in mixture throughout thickness, non-glaring, black color, having the following minimum properties as tested in accordance with referenced ASTM designations:

Flexural strength	D790	11,300 psi
Compressive strength	D695	30,500 psi
Hardness, Rockwell M	D785	108.
Flammability	D635	self extinguishing
Water absorption, percent by weight, maximum in 24 hr. = D570 +0.019%		

Chemical resistance – following ratings when tested with indicated reagents according to NEMA LD 3, test procedure 3.9.5:

Reagent	Result
Acetic acid, glacial	no effect
Acetone	moderate effect
Ammonium hydroxide, 28%	moderate effect
Amyl acetate	no effect
Benzene	no effect
Butyl alcohol	no effect
Calcium hypochlorite	no effect
Chloroform	moderate effect
Chromic acid, saturated	severe effect
Ethyl acetate	moderate effect
Ethyl alcohol	no effect
Dichromate cleaning solution	severe effect
Formaldehyde	moderate effect
Hydrochloric acid, 37%	no effect
Hydrogen peroxide	moderate effect
Kerosene	no effect
Methyl alcohol	no effect
Nitric acid, 70%	moderate effect
Phenol	moderate effect
Silver nitrate, 10%	no effect
Sodium hydroxide, 10%	no effect
Sodium hydroxide, 50%	moderate effect
Sulfuric acid, 33%	moderate effect
Sulfuric acid, 96%	severe effect
Trichloroethylene	no effect
Xylene	no effect
Zinc chloride, saturated	no effect

B. Stainless Steel
1. ASTM A167, Type 304, No. 4 finish, unless otherwise specified.

C. Sheet Steel
1. ASTM A366 and free from scale, pits, buckles and other imperfections. Sheet steel for surfaces exposed to view: stretcher leveled.

D. Aluminum
1. Extruded aluminum: ASTM B221, alloy 6063-T42 or 6063-T5.

E. Polyvinylchloride (pvc)
1. Type I unplasticized polyvinylchloride.

F. Adhesive
1. Adhesive for joining molded resin tops and backsplashes and for sealing sinks and drain troughs to tops: two-component epoxy compound.

G. Glass
1. ASTM C1036, Glass for framed doors: dsb.
2. Safety glass for metal fume hoods: sheets of float glass separated by clear plastic interlayer.

H. Sealant
1. Epoxy sealant: two-component epoxy compound.
2. Silicone sealant: one-part water base silicone sealing compound, Dow Corning Corp. “Trademate” Tile & Fixture Sealant, or as approved, in custom color matching color of surface to be sealed.

I. Table Leg Shoes
1. 63-mm high (2- 1/2 inch high) vinyl with bottom coved, color to match base selected by the Architect for the room finish.

J. Fixture Materials
1. Chromium-plating: an electro-deposited copper-nickel-chromium coating. Minimum thickness of chromium: 1.3 micrometers (0.000015 inch).

2.4 METAL CABINET CONSTRUCTION

A. General
1. Provide cabinets of modular construction so that the various units can be combined in assemblies to fit the floor plan and functional requirements of the facility.
2. Durable, sturdy, dust-tight.
3. Designed to provide easy access for installation and maintenance of plumbing and electrical work.
4. Shut-off valves and plumbing traps in service chase assemblies accessible with cabinets in place. Coordinate access panel requirements with plumbing work.
5. Paint Color: To match Fisher Hamilton PW Petal White 1362

B. Drawers
1. One-piece bottom and sides formed in channel shape at top and flanged at back and front, welded to drawer back and drawer front (painted steel or stainless steel).
2. Two-piece drawer front, 16-mm (5/8-inch) minimum thickness, fully sound deadened, fitted with rubber bumpers, corners welded and ground smooth, painted on inside before assembly.
3. Drawer channel die-formed and welded to drawer side, with hardened steel, cadmium-plated, ball-bearing roller.
4. Operation: Smooth and quiet for a minimum of 10,000 in-out cycles with a 68-kg (150-lb.) load evenly distributed in drawer.
5. Maximum force required to open a drawer: 3 percent of unloaded or loaded drawer weight.
6. Type: Full drawer extension type.

C. Doors
1. Hinged doors: double wall construction, 16-mm (5/8-inch) minimum thickness, fully sound deadened, corners welded and ground smooth, with inside surfaces painted before assembly; reinforced at hinge and pull locations and fitted with two rubber bumpers.
2. Support, without sagging, a 90-kg (200-lb.) load applied at top edge while door is being swung. Swing: 180 degrees.

3. Deflection: For a door 1980 mm (78 inches) high x 559 mm (22 inches) wide x 19-mm (3/4 inch) thick when tested with an applied force of 178 N (40 lb) as follows: for smaller doors, proportionately smaller deflection:

Test	Maximum temporary deflection	Set
Center beam test	0.06 inches	0
Corner torsion twist test	0.25 inches	0.03 inches

D. Closure Panels and Fillers
1. Provide closure panels to enclose space between ceiling and cabinets and between ceiling and fume hoods where indicated. Provide fillers between wall and cabinets and between cabinets and fume hoods, and between fume hoods.
2. Filler panels between metal cabinets and wall or between metal cabinets and fume hoods: metal and finished to match metal cabinets. Closure panels: fabricated of sheet steel, channel-shaped.

E. Performance Requirements for Finish on Metal Cabinets
1. Perform chemical resistance tests by applying 10 drops of each of the following reagents to the surface for one hour under watch glass, washing surface with soap and water and drying before examination.

Sulfuric acid	38 percent
Hydrochloric acid	37 percent
Nitric acid	30 percent
Phosphoric acid	75 percent
Formic acid	88 percent
Acetic acid-glacial, sodium hydroxide	20 percent
Ammonium hydroxide	28 percent
Hydrogen peroxide	5 percent
Ethyl alcohol, ethyl acetate, ethyl ether, xylene, acetone, phenol	85 percent
Formaldehyde, carbon tetrachloride	85 percent

2. Perform moisture resistance tests as follows:
   a. Soak sponge or felt in cold water and apply to surface for 100 hours and dry surface before examination.
   b. Trickle boiling water over surface inclined at 45 degrees for 5 minutes and dry before examination.
3. Provide a finish which shows no visible effect on finish film other than slight change of gloss visible only from a grazing angle.

2.5 WOOD CABINET CONSTRUCTION

A. General
1. Door and drawer fronts of mobile casework only
2. Solid Wood: Air-dried to 4.5 percent moisture content, then tempered to 6 percent moisture content before use.
3. Species and Cut: Hard maple, plain sliced
4. Grain: Vertical match

2.6 CABINET HARDWARE

A. General
1. Catches: nylon roller type or spring-actuated, roll point type.

2. Drawer guides: full extension, ball bearing roller, 100-pound class, epoxy-coated, Accuride or as approved.
3. Full extension, ball bearing, 150-pound class for all file drawers.
4. Drawer and door pulls; stainless steel wire, mounted horizontally on drawers and vertically on doors.
5. Provide single doors and active leaf of pairs of doors for hinged, full height cabinets with an active knob and vertical sliding bolt assembly. Provide inactive leaf of pairs of doors for full height cabinets shall with astragal strip and dummy knob. Vertical sliding bolts: concealed in the stiles of glazed doors and between pans of solid doors to engage stainless steel keepers.

B. Pulls
1. Provide two pulls on drawers wider than 710 mm (28 inches).

C. Hinges
1. 63-mm (2-1/2-inch) heavy duty stainless steel institutional type, attached with flathead screws. For doors over 910 mm (36 inches) high, provide 1-1/2-pair of hinges.

D. Keying
1. Unless otherwise directed, key locks differently within a room, differently between rooms. Master key all locks.
2. Provide satin chromium-plated brass cylinder 5-pin locks for doors and drawers indicated to be locked. Provide controlled key blanks and registered key plan, 2 keys for each lock keyed differently, and 2 master keys for each master keyed group.

2.7 COUNTERTOPS

A. General
1. Provide countertops and backsplashes of the same material with minimum 0.26 meters (2 feet) and, up to and including 2.4 meters (8 feet) in length in one piece. Where countertops exceed 2.4 meters (8 feet) in length, provide concealed field joints of flush-bolt construction or other approved construction.
2. Provide cutouts for required service fixtures and sinks.

B. Molded Resin Tops
1. 25-mm-thick (one-inch-thick) top with 100-mm-high (4-inch-high) and 19-mm-thick (3/4-inch-thick) curbs. Provide drip groove at underside of exposed edges and round exposed corners.
2. Curbs at sides of tops, fume hoods and casework components where indicated: butt jointed and bonded to the surface of top to form a square joint.
3. Backsplash curbs: butt jointed and bonded to the surface of top to form a square joint.
4. Color: Black
5. Molded resin at sink units 1 ¼” thick

C. Stainless Steel Tops
1. Fabricated of 1.511-mm (16 gage) stainless steel with the following provisions;
   a. Exposed edges formed into channel shape. Edge of top 25 mm (one inch) high, plus raised rim for tops with sinks.
   b. Underside reinforced to prevent twisting, oil canning or buckling and coated with sound deadener.
   c. Backsplashes, curbs and integral sinks in one piece with top or continuously welded to top, welds ground smooth and welding flash removed. Provide drainboard adjacent to sinks.
   d. Field joints tightly butted and held in alignment with steel reinforcement.
   e. Wood inserts in edges of top for anchorage.
   f. Strippable plastic coating on finished surfaces for protection.

2.8 SINKS

A. Stainless Steel Sinks
1. Sink Types:
a. SK-1 – Stainless Steel under-mount countertop sink
b. SK-5 – Stainless Steel dual compartment stand alone sink unit
2. 1.3-mm (18 gage), unless otherwise specified, with joints welded, ground smooth and polished, inside corners coved and bottom pitched to drain outlet. Form top edges of sinks in other than stainless steel tops with self-rimming flange. Provide sound-deadener spray applied to underside of sinks.
3. Sinks more than 250 mm (10 inches) deep or more than 2430 mm (96 inches) in perimeter: 1.6 mm (16 gage).
4. Fit each stainless steel sink with a stainless steel sink plug, 38 mm (1-1/2 inches), with integral cross bars, removable strainer, inlet tapered for overflow, and 1.6-mm (16 gage) threaded tailpiece, complete with washer and locknut.

B. Molded Resin Sink
1. Sink Types: SK-2, SK-2E, and SK-3
2. One-piece construction with all inside corners coved and bottom pitched to drain outlet and fitted with a molded resin sink plug, 38 mm (1-1/2 inches) with integral cross bars, removable strainer, inlet machined for overflow, and threaded tailpiece, complete with washer and locknut.
3. Under-mount type sinks at countertops unless indicated otherwise.
4. Provide proper hanger support for sink.
5. Manufacturers: Durcon Co. Inc., Epoxyn Products, or as approved; color same as countertops.

C. Cup Sinks
1. Molded resin, oval flanged type, 150 x 75 mm (6 x 3 inches) inside dimension, with integral cross bars, removable strainer and threaded tailpiece.

D. Sink Sizes (L x W x D)
1. Single bowl, epoxy resin:
a. Type 1 (SK-1 and SK-2) – 22 x 16 x 8 inches
b. Type 2 (SK-3) – 28 x 18 x 10 inches
2. Double bowl, stainless steel each bowl:
a. Type 3 (SK-5) – 20 x 20 x 10 inches

2.9 SERVICE FIXTURES

A. General
1. Furnish mechanical and electrical fixtures to be mounted in or in conjunction with casework.

B. Mechanical Fixtures - General
1. Identify mechanical services with full view colored index buttons in accordance with U.S. Standard Color Code.
2. Colored epoxy coated brass by Water Saver Faucet Co. or equivalent models as manufactured by Chicago Faucet Co. or T & S Brass and Bronze Works. Equip faucets with laboratory serrated hose ends or aerators as indicated. Provide factory assembled shanks for deck mounting or panel mounting. Color to match table upright paint color (Thermo Scientific PW Petal White 1362).

C. Water Fixtures
1. Provide renewable units containing all working parts, including a monel or stainless steel replaceable seat. Provide an integral volume control in the renewable unit or in the inlet or outlet of the fixture.. Provide convertible rigid/swing goosenecks with 180-degree stops. Provide 180-degree handle/gooseneck configuration at cup sinks.
2. Acceptable manufacturers:

a. Water Saver (Basis of Design)
b. Encon
c. Chicago Faucets

3. Provide water fixtures as indicated and as follows:
   a. Item MF: Mixing faucet with vacuum breaker gooseneck, laboratory type, with serrated hose end. (Water Saver model no. CTFS4414VB) (for SK-2E only Water Saver model no. L4511-303)
   b. Item DI: Gooseneck type faucet, with internal polypropylene lining, disk type valve, teflon washer and self-closing operated handle; a serrated laboratory hose end; used for deionized water. (Water Saver model no. CT7853SC) (for SK-2E only Water Saver model no. L4511)
   c. Item CW: Gooseneck type faucet with single manual operated handle for cold water only, vacuum breaker gooseneck with a serrated hose end. (Water Saver model no. CTFS3911VB)
   d. Item ADA: Gooseneck type mixing faucet with 114-mm (4-1/2-inch) type wrist blades and aerator. (Water Saver model no. CTFS4414VB-BH)
   e. Item: EW: Deck mounted swing-down unit, autoflow. (Water Saver model no. CTEW849); refer to drawings for configuration.
   f. Pre-rinse Fixture: Deck-mounted pre-rinse unit for hot and cold water. (Water Saver model no. PR411)
   g. Item ADA DI: Gooseneck type faucet, with interior polypropylene lining, disk type valve, Teflon washer and self-closing lever operated handle; a serrated laboratory hose end; used for deionized water. (Water Saver model no. CT7853SC-LE)

D. Air and Vacuum Fixtures
1. Provide stainless steel floating needle and removable stainless steel seat for air and vacuum valves. Action of valve: slow compression for fine control under pressures up to 690KPa (100 PSI).

E. Flammable Gas Fixtures
1. Provide a stainless steel ball valve at flammable gas valves at pressures up to 1/2 PSI. Provide American Gas Association certification.
2. Provide turret base for fixtures indicated to be deck mounted. For fixtures (GC-1), provide one cock. For fixtures (GC-2), provide two cocks, each set at 180 degrees.

F. Electrical Fixtures
1. Refer to Electrical Div 26 “Wiring Devices” for receptacle type and color.
2. Faceplates: brushed stainless steel with configurations to mate with pedestals, wiring devices and telecommunication devices as indicated.
3. Pedestals as manufactured by Water Saver Faucet Company “ColorTech” or as approved.
   a. UL listed and furnished with grounding screws, mounting shanks, and locknuts.
   b. Powder coated finish with standard color to be determined by Architect.

G. Task Lighting
1. Fixtures: Low-profile, fluorescent, with T8 lamps, UL-labeled.
2. Ballasts: electronic, located in the fixture.
3. Satin aluminum light housing, with stainless steel mounting straps.
4. Plug-in, independently switched type. Minimize cord length.
5. Acrylic diffuser
6. Maximize length to mounting surface where required, provide each bench with either 2 foot or 4 foot light fixtures. Coordinate location and mounting method.
7. Design lighting to provide light level of 50 foot-candles when measured at 36 inches above finished floor.
8. Refer to Electrical Specification Section 26 51 00 “Interior Lighting” for lamp and ballast types.

2.10 DRYING RACKS

A. Stainless steel, no. 4 finish, back with polypropylene pegs, inclined at 45-degree angle upward.

B. Pegs at 6-inches long.

C. Integral drip trough with stainless steel screen insert and 36 inch drain hose.

2.11 GROMMETS

A. Plastic grommets, color to be selected

B. Provide with “flip top” cap and regular liner for each

C. Provide with 3-inch diameter hole.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protection
1. Protect the Work and adjacent construction from damage during installation and subsequent operations under the Contract.

3.2 DELIVERY

A. Deliver casework systems in two stages:
1. Deliver fixed casework and fume hoods.
2. Deliver flexible casework systems.

B. Deliver flexible casework systems just prior to building occupancy, as directed by the Construction Manager.

3.3 INSTALLATION

A. General
1. Install casework and fume hoods in accordance with manufacturer's instructions and approved Shop Drawings, and under the supervision of the manufacturer's trained personnel.
2. Casework
   a. Completely install casework less installation of mechanical and electrical service fixtures and final connection to services.
   b. Installation of service fixtures and final connection to services are specified in Divisions 22, 23 and 26.
3. Fume hoods
   a. Completely install fume hoods less final connection to services.
   b. Final connection to services is specified in Divisions 22, 23 and 26.
4. Overhead service drops
   a. Completely install service drops less final connections to services.
   b. Final connection to services as specified in Division 22, 23 and 26.

B. Casework Assemblies
1. Assemble cabinets in the field with provision for future relocation, connected together with concealed bolts and set level and in alignment.
2. Install leg shoe on each table leg.

3. Provide all fastening devices, supports, adhesive and fillers required for a complete installation, including the following:
   a. Metal grounds bolted to stud partitions for support of wall cabinets.
   b. Hanger supports for sinks.
   c. Bolts and expansion shields for items connected to masonry walls.
   d. Strut assemblies for support of fume hood superstructures or other heavy equipment and for drain troughs and piping.
   e. Closure panels to ceiling, exposed ends closed.
   f. Fillers required to enclose space between wall and cabinets or fume hoods.
4. Provide holes and cutouts required for installation of equipment indicated to be mounted to casework, including items furnished under other Sections and items indicated to be not included in the Contract. Coordinate location of utilities.
5. Provide galvanized backer plates at toe kicks to receive applied base where floor elevation deviations cause gaps over one inch between bottom of cabinet base and floor.
6. Coordinate with installers of wood blocking or metal reinforcing in stud partitions to correctly locate the blocking/reinforcing.

C. Countertops and Sinks
1. Anchor tops to base cabinet (or support structure) and knee space assemblies utilizing a construction adhesive such as "Liquid Nail" or a Ply 400/Ply 200 adhesive.. Install drain troughs and sinks and sealant required to seal against tops. Remove plastic coating from stainless steel surfaces.
2. Use epoxy sealant for molded resin tops and sink plugs and silicone sealant for stainless steel tops and sink plugs.
3. Installation of sink fittings is specified in Division 22. Install sink plugs and fill annular space around top of sink plugs with sealant.
4. Set backsplashes and curbs in a full bed of adhesive. Seal joints in tops, backsplashes and curbs with adhesive.
5. Seal the following joints with silicone sealant:
   a. Joints between backsplashes and vertical surfaces, including partitions and column enclosures.

D. Accessory Equipment
1. Install accessory equipment ready for final connection to services.

E. Cylinder Restraint
1. Anchor cylinder restrain to wood blocking or metal reinforcing in stud partitions at height indicated.

3.4 ADJUSTTING

A. Make final adjustments required for proper operation as determined by the Architect.

B. Level and adjust all flexible casework systems (tables and movable benches) once these systems are placed in their designated locations.

3.5 CLEANING

A. Following completion, clean finished surfaces and leave work free of imperfections. Touch up damaged finish equal to original condition as approved.

END OF SECTION

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SECTION 12 31 01

HIGH PERFORMANCE LABORATORY FUME HOODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Section 12 31 00 – General Requirements for Casework and Fume Hoods

C. Section 12 31 03 – Flexible Casework Systems

D. Section 12 31 04 – Metal Laboratory Casework

E. Related Work Specified Elsewhere
1. Final connection to services are specified in Divisions 21 through 28 and indicated on the Mechanical, Electrical, and Plumbing drawings.

1.2 REFERENCES

A. Scientific Equipment and Furniture Association 2008, Third Edition, (SEFA)
1. Laboratory Fume Hoods.
2. Laboratory Furniture, Casework, Shelving and Tables.
3. Installation of Scientific Laboratory Furniture and Equipment.

B. Underwriters Laboratories (UL)
1. 1805 Laboratory Hoods and Cabinets.

C. American Society of Heating, Refrigeration and Air-conditioning Engineers (ANSI/ASHRAE)
1. 110-1995 Method of Testing Performance of Laboratory Fume Hoods.

D. National Fire Protection Association (NFPA)
1. 30 Flammable and Combustible Liquids Code, 2008 Edition.

E. American Society for Testing and Materials (ASTM)
1. D635 – Test Method for Rate of Burning and/or Extend and Time of Burning of Self-Supporting Plastics in a Horizontal Position.

1.3 DEFINITIONS

A. The concept of the High Performance Laboratory Fume Hood is to allow a fume hood to operate with up to 50% less exhaust air than a traditional hood but improving containment. The hood shall have a specially designed aerodynamic combination horizontal / vertical sash, specific modifications to the superstructure and an automatic positioning baffle to enhance containment. The High Performance Laboratory Fume Hood shall incorporate integral controls to enhance containment reacting to variables which could affect containment, including sash movement, hood loading, cross-drafts, personnel movement and other variables potentially affecting containment.

B. Fume hood sash shall be full view type providing a clear and unobstructed side to side view of fume hood interior. Sash shall be laminated safety glass set into extruded polyvinyl chloride guide. Glass shall be set into rails with PVC glazing channel. Bottom of sash glass shall be ground and polished. In order to maintain sightlines, no edging or full width bottom handle shall be used. A powder coated curved tubular sash handle shall be provided and attached to sash glass using screws and resilient bushings to prevent glass chipping. A single weight, chain, bearing and shaft, counter balance system shall be used for vertical operation of sash and prevent jamming to permit one finger operation at any point along full width sash pull. Sash system shall be designed to prevent sash drop in the event of chain or cable failure. Superstructure shall have a single sash and counter balance system. Sash shall open and close against rubber bumper stops.

C. Fume hoods shall have combination sashes both vertical and horizontal. Sensors for sashes shall be coordinated for amount and location per manufacturer

D. Fume hoods will be operated at 80 fpm.

1.4 PROJECT CONDITIONS

A. Field Measurements
1. Take field measurements to verify or supplement dimensions indicated. Be responsible for accurate fit of the Work.
2. Verify that all equipment in this section is coordinated to provide a complete working process and system integration

B. Utilities Verification
1. Utilities and connections may vary between approved manufacturers.
2. All utilities for these items are indicated in mechanical and electrical documents and are referenced in Divisions 15 and 16 / 21 through 28. Any deviations from these utilities must be documented within bid and shop drawing submittals.

1.5 ACTION SUBMITTALS

A. Product Data: Submit complete catalogue data, including a chart of manufacturer's standard finishes for all materials, equipment and products for work in this section.

B. Shop Drawings: Submit complete shop fabrication and installation drawings, including scaled plans, elevations, sections, details and schedules. Show relationship to adjoining materials and construction. Shop drawings shall not exceed 11 inches x 17 inches in size.

1.6 CLOSEOUT SUBMITTALS

A. Test Reports: Submit complete reports verifying conformance to performance standards outlined in this specification when tested to the ASHRAE 110 Standard in both the "As Manufactured" and "As Installed" environment.

1.7 QUALITY ASSURANCE

A. Contractor for work in this section shall have an established organization and production facilities including all tools, equipment and special machinery necessary for specializing in the fabrication and installation of the type of products specified with skilled personnel, factory trained workmen and an experienced engineering department. Each shall have the demonstrated knowledge, ability and proven capability to produce the specified equipment of the required quality and the proven capacity to complete an installation of the size and scope of this project within the required time limits. A minimum of 10 years experience in the manufacture

of laboratory fume hoods is required. A minimum of 5 years experience in the manufacture of high performance fume hoods is required. Manufacturer must have an installed population of at least 1000 high performance fume hoods installed and operating in the United States.

B. Source Limitations: Obtain laboratory fume hoods and the laboratory casework below the fume hoods through one source from a single manufacturer.

C. Product Standard (General): Comply with SEFA 1-2008, Laboratory Fume Hoods, or most current published edition.

D. Product Standard (Construction): All laboratory fume hood shall be Classified by Underwriters Laboratories under UL Standard 1805.

E. Each Fume Hood is to be individually tested in the field per ASHRAE 110.1995.
   1. Product Standard (Performance): Achieve a performance rating of 4.0 AM 0.01 or better for all tracer gas tests conducted on all of the fume hood designs per the ASHRAE 110-1995 test, or the most current published edition.

1.8 PERFORMANCE REQUIREMENTS

A. Operation of Metal Fume Hoods.
   1. Design high performance laboratory fume hoods to operate at the total cfm indicated and a maximum static pressure as follows, between 60 to 80 fpm face velocity:

Width	Static Pressure
Feet	Inch w.g.
4	0.09
6	0.09

B. Hood Design
   1. Design the fume hood so that, when properly installed in a laboratory and connected to an exhaust system of the proper capacity, it will contain and remove fumes generated within the hood and will exhaust light or heavy gases efficiently.
   2. “Properly installed” means installed in an area where there is at least 5 feet of clear space in front and sufficient space on each side for observation of the airflow pattern entering the hood and where there are no cross drafts or other air currents exceeding 10 fpm that would affect the hood performance in the area in front and around the hood.
   3. Design hood to maximize user safety and energy conservation, to operation on room air only with no auxiliary air supply, to provide a constant sweep of air through the hood, obtained over an airfoil sill, when the sash is closed, and to maintain a constant face velocity when the sash is open at any position.

C. Verification of Fume Hood Face Velocities
   1. With exhaust system in operation, determine the quantity of air being exhausted by measuring the velocity of the air entering the hood face, and multiplying this velocity by the square feet of hood opening. Determine the air velocity by averaging at least six velocity readings taken in the center of a grid made up of 3 sections across the top half of the hood face and 3 sections across the bottom half of the hood face. Maximum variation of readings from the average face velocity: plus-or-minus 10 fpm.

D. Air Flow – General

1. When the selected face velocity has been established and verified, perform the following tests:
   a. Make a complete traverse of the hood face with a cotton swab dipped in titanium tetrachloride to demonstrate that a positive flow of air is maintained into the hood over the entire hood face. No reverse air flow or dead air space will be permitted.
   b. Paint a strip of titanium tetrachloride along each end and across the working surface of the hood, in a line parallel with the hood face and 6 inches back into the hood to demonstrate that no back flow of air exists at these points and that flow of smoke is directly to the rear of the hood, without swirling turbulence or reverse flow.
   c. Discharge a smoke bomb (one half-minute size), as available from Metermall Company) within the hood area to show the exhaust capability of the hood and its design efficiency. No reverse air flow will be permitted. Place lighted bomb in the hood area and move it to various places, checking end panels and working surface to verify that no reverse air flow exists at any point. Lower the sash to closed position to verify that a sufficient air volume is flowing through the hood work area to carry away fumes from a massive fume source. Verify that, within one minute after the smoke bomb stops discharging smoke, the hood area is purged of smoke.
2. Repeat the above test for every face velocity setting selected to be tested in the 50-60 fpm to 70-80 fpm range.
3. Provide a fume hood automatic air bypass to maintain a relatively constant flow of air into the hood at all sash positions, and, when the sash is down, to control the maximum air velocity being drawn through the hood so that it does not exceed 4-1/4 times the face velocity when the sash is full open.

1.9 SPECIAL WARRANTY

A. Manufacturer shall provide a minimum three (3) year warranty on parts and labor to repair or replace defects in materials and workmanship for fume hoods and casework.

PART 2 - PRODUCTS

2.1 HIGH-PERFORMANCE LABORATORY FUME HOODS

A. Design Requirements:
1. Fume hoods shall function as ventilated, enclosed works paces, designed to capture, confine and exhaust fumes, vapors and particulate matter produced or generated within the enclosure.
2. Fume hood shall operate safely with an average face velocity of 80 FPM through the fully opened vertical sash.
3. Design fume hoods for consistent and safe air flow through the hood face. Negative variations of face velocity shall not exceed 20 percent of the average face velocity at any designated measuring point as defined in this section.
4. Average illumination of work area: Minimum 80 Footcandles. Work area shall be defined as the area inside the superstructure from side to side and from face of baffle to the inside face of the sash, and from the working surface to a height of 28 inches.
5. Fume hood shall be designed to minimize static pressure loss with adequate slot area and bell shaped exhaust collar configuration.

B. Manufacturers: Subject to compliance with specified requirements, provide products by one of the following:
1. Bedcolab, Ltd., Vanguard
2. Jamestown Metal Products, Isolator 2
3. Kewaunee Scientific Equipment Corp., Supreme Air LV
4. Mott Manufacturing Limited, Safeguard
5. ALC / Thermo Fisher Scientific (Hamilton), Concept

C. Materials:

1. All materials shall be of the highest quality and appropriate for intended use.

D. Construction Features:
1. Superstructure:
   a. Wall: For safety related to physical structural support superstructures shall be double wall type with outer wall of polyurethane-coated steel and the inner galvanized wall, covered with 1/4" thick chemically resistant white fiberglass reinforced polyester. The exterior shall be constructed of 18 gauge C.R.S. finished in reagent resistant catalytically activated polyurethane, color selected from manufacturer's standard color chart by architect/lab planner. The interior wall shall be securely held in place with concealed fastenings with corrosion protection. Hoods shall be completely factory assembled to form a rigid, self-supporting structure.
   b. Dimensions: High-line Fume Hood Superstructure.
   c. Bypass: By-pass air is introduced below the sash through multi-channel slots in airfoil, when the sash is closed. All air shall enter the hood through the sash opening and through multi-vector slots below the sash.
   d. Ceiling closure panel: Minimum 18 gage thick, finish to match hood.
2. Face Opening:
   a. The following requirements are to prevent reverse eddy airflow. Area surrounding sash opening to be rounded to create an aerodynamic configuration with side posts maximum 4.5 inches in width. Side posts to incorporate an airfoil design.
   b. Air foil: A multi-vector airfoil bypass and dynamic turning vane shall be mounted behind the sash. This airfoil shall be attached via spring loaded pins to hood allowing swing-up for line cord access. Bottom foil to be constructed of steel with a chemical resistant powder-coat finish or stainless steel.
   c. Removable: Hood front section shall be removable to facilitate the hood's access to its final location. Fume hood front to include posts, tracks, sash with weight, pulleys, cable, foil, plumbing fixtures and pre-wired electrical fixtures. Fume hood front with sash and pre-wired electrical components, including the light box, are to be removable from hood body as a complete assembled one piece unit (only using quick disconnects for the cable components or electrical components).
3. Color Selection: To match Thermo Scientific PW Petal White 1362.
4. Sash:
   a. Full view type with clear, unobstructed, side to side view of fume hood interior and service fixture connections.
   b. Automatic sash operator to automatically close sash when fume hood is unoccupied
   c. Sash shall be aerodynamically designed construction with chemically resistant coating, combination style with both vertical and horizontal moving glass panels. Horizontal sliding sashes are on two tracks. Each panel must ride on top hung rollers supported from top rail only. The sash mechanism shall be so designed to allow it to move below the counter top. Maximum sash opening to be 28 inches. An additional 7 inches high, clear glass panel integrated as part of Hood lintel shall maintain a clear vision height of 34 inches above countertop.
   d. Counter balance system: chain and sprocket system shall prevent sash tilting and permit one finger operation at any point along full width pull. Design system to hold sash at any position without creep and prevent sash drop in the event of cable failure. Sash and counterbalance mechanism to be life cycle tested to withstand a minimum of 100,000 cycles without signs of fatigue. Open and close sash against rubber bumper stops. Sash Chain: #35 hardened. Hardened sprockets with one full width shaft per sash running in ball bearings.
   e. Coordinate sash sensor installation with laboratory HVAC instrumentation and control.
   f. Liners: Fiberglass reinforced polyester, 1/4 inch thick. Color: white. These panels to have at least a "Laboratory Grade finish" when tested per the chemical spot test in the Scientific

Equipment and Furniture Association (SEFA) SEFA 8-2008 Standard. Chemical resistance test data to be supplied to the Owner for his evaluation for intended use, upon Owner request.

5. Baffles:
   a. Chemically resistant powder coated pre-set aluminum, fixed baffle with slots at top, center and bottom. Baffle to maintain containment with sash movement, cross drafts and other factors. Chemical resistance test data on baffle coating to be supplied to the Owner for his evaluation for intended use.
6. Work Surfaces:
   a. Epoxy resin, 1 inch thick. Color: to match casework tops in same room.
   b. Provide 1/4 inch raised edge on the entire perimeter of the countertop and around cup-sink areas creating a dished work area.
7. Exhaust Outlet:
   a. Bell mouth exhaust collar sized per fume hood size / model number.
8. Instruction Plate:
   a. Silk-screened instructions on fume hood exterior with condensed information covering recommended locations for apparatus and accessories, use of sash, and recommended safe operating procedures.
9. UL Label:
   a. Clearly visible label affixed to hood front identifying fume hood as UL Classified. List the UL file number for verification of UL Classification.

E. Airflow Monitor:
1. Coordinate installation of the hood airflow monitor such that it alerts the user when the average face velocity falls below the Owner set point. Monitor must provide a digital readout of the velocity or an alpha text message of the hood condition, with the LED's indicating normal and alarm conditions. Fume hood flow monitor as specified in Division 23 09 33.

2.2 SERVICE FIXTURES

A. Mechanical Fixtures
1. General
   a. Include piping from service connection at top of hood to valves, mounted in fume hoods. Include piping insulation for all water services.
   b. Fixture surfaces exposed on interior of hood coated with acid-and-solvent-resistant finish baked on to minimum dry film thickness of 2 mils.
   c. Identify mechanical services with colored index buttons or colored handles in accordance with U.S. Standard Color Code.
   d. See Section 12 31 00, "General Requirements for Casework and Fume Hoods" for fixtures selection.
2. Valves
   a. Front load type with four-arm control handle, including piping from valves to outlets.
3. Industrial Water
   a. Fixed gooseneck type with renewable units containing all working parts including a monel or stainless steel replaceable seat. Provide an integral volume control contained in the renewable unit or in the inlet or outlet of the fixture. Provide code-compliance vacuum breaker located on front face of hood.
4. Air and Vacuum
   a. Provide a stainless steel floating needle and removable stainless steel seat for air and vacuum valves. Action of valve: slow compression for fine control under pressures up to 100 psi.
5. Gas
   a. Provide a stainless steel floating needle and removable stainless steel seat for non-flammable gas valves. Action of valve: slow compression for fine control under pressures up to 100 psi.

b. Provide a stainless steel ball valve for flammable gas valves at pressures up to 1/2 PSI. Provide American Gas Association certification.

B. Electrical Fixtures
1. Pre-wire electrical equipment in fume hood to 2 junction boxes mounted on top of each hood: one for air flow monitor and one for electrical accessories.
2. Electrical Receptacles: Provide each hood with two 120 volt, 20 amp, GFI duplex receptacles.
3. Refer to electrical specification 26 27 26 “Wiring Devices” for receptacle type and color.
4. Lights: Provide each hood with a two-lamp 4 foot light fixture. Equip each fixture with two T-8, straight tube, rapid-start, multi-phosphor fluorescent lamps with a medium bi-pin base, color temperature of 4100 deg K, and a CRI of not less than 82.

C. Refer to electrical specification 26 51 00 “Interior Lighting” for lamp and ballast type.
a. Shield light from hood interior by 1/4 inch thick safety glass or 1/8 inch thick tempered glass panel, sealed air tight into hood body with chemical resistant rubber channels. Set units so the light lamps are easily replaceable from outside hood.
b. Provide switch marked “Fume Hood Light” on face of hood.
1) Refer to electrical specification 26 27 26 “Wiring Devices” for switch type and color.
c. Provide only fixtures, which carry the Underwriter’s Laboratory (UL) label.
2. Provide wiring devices as specified in Division 26.

2.3 GENERAL PURPOSE HOOD (EQ-057, EQ-058, EQ-059)

A. Construction
1. Width: 4 feet (EQ-057), 5 feet (EQ-058), or 6 feet (EQ-059).
2. Bench – Top.
3. Metal fume hood with combination sash and general purpose interior construction.
4. Sidewalls of superstructure shall be approximately 3-1/2 inch thick and contain the mechanical and electrical service fixtures.
5. Shipped in one section.
.

2.4 ADA ACCESSIBLE FUME HOOD (EQ-057A, EQ-058A, EQ-059A)

A. Construction
1. Width: 4 feet (EQ-057A), 5 feet (EQ-058A), or 6 feet (EQ-059A).
2. Bench – Top.
3. Metal fume hood with combination sash and general purpose interior construction.
4. Sidewalls of superstructure shall be approximately 3-1/2 inch thick and contain the mechanical and electrical service fixtures.
5. Shipped in one section.

B. Accessibility
1. Hood shall meet accessible requirements as defined by ANSI A117.1, Accessible and Usable Building and Facilities.
2. Fume hood must be mounted on nominal 29 inch high base cabinets. All service fixtures and controls should be mounted for easy reach from a seated wheel chair position. No control on the post shall be mounted higher than 20 inches from the fume hood work surface. No hood service in the hood shall be mounted deeper than 23 inches from the fume hood sash. Cabinet configuration below the fume hood shall have a minimum 36 inch wide knees space area for wheelchair access.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fume hoods and equipment in accordance with manufacturer's instructions.

B. Install equipment plumb, square, and straight with no distortion and securely anchored as required.

C. Secure work surfaces to casework and equipment components with material and procedures recommended by the manufacturer.

D. Provide aluminum channel supports and reinforcing for wall mounted shelving specified in Laboratory Casework Section, with approved anchorage to wall panels.

E. Accessory Installation: Install accessories and fittings in accordance with manufacturer's recommendations.

3.2 ADJUSTING

A. Repair or remove and replace defective work, as directed by the Owner's Representative upon completion of installation.

B. Adjust sash, fixtures, accessories and other moving or operating parts to function smoothly.

3.3 CLEANING

A. Clean equipment, touch up as required.

3.4 PROTECTION OF FINISHED WORK

A. Provide all necessary protective measures to prevent damage to equipment from exposure to other construction activity.

B. Advise Contractor of procedures and precautions for protection of material and installed fume hoods from damage by work of other trades.

3.5 TRAINING

A. Upon completion of the installation of the fume hoods, manufacturer must conduct a training seminar for the Owner's users at the job site discussing proper operation of the fume hood, fume hood features and best use practices. Training session must be at least one hour in length, not including a question and answer session. Training session must be scheduled within 30 days on completion of the installation.

END OF SECTION

SECTION 12 31 03

FLEXIBLE CASEWORK SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Section 12 31 00 – General Requirements for Casework and Fume Hoods

C. Section 12 31 04 – Metal Laboratory Casework

D. Related Work Specified Elsewhere
1. Final connection to services are specified in Divisions 21 through 28 and indicated on the Mechanical, Electrical, and Plumbing drawings.

1.2 REFERENCES

A. Scientific Equipment and Furniture Association 2008, Third Edition, (SEFA)
1. Laboratory Furniture, Casework, Shelving and Tables.
2. Installation of Scientific Laboratory Furniture and Equipment.

B. Underwriters Laboratories (UL)
1. 1805 Laboratory Hoods and Cabinets.

C. American Society of Civil Engineers (ASCE)
1. 7 – Minimum Design Loads for Buildings and Other Structures

D. National Fire Protection Association (NFPA)
1. 30 - Flammable and Combustible Liquids Code, 2008 Edition.

1.3 SYSTEM DESCRIPTION

A. Design Requirements
1. Provide modular structural components for support of work surfaces, under counter cabinets, and overhead storage components which are essentially self supporting and independent of the building structure.
2. Vertical height of movable bench and table work surfaces and shelves can be adjusted with simple, positive mechanisms.

B. Performance Requirements
1. Structural performance: Provide support framing capable of withstanding the total live loads indicated for various system designs including weight applied to the top of work surface and total weight of below-counter storage units and other accessories.
2. Seismic performance: Provide modular laboratory casework system capable of withstanding the effects of earthquake motions determined according to the building code in effect for this Project or ASCE 7, Section 9, "Earthquake Loads," whichever is more stringent.
a. The Effective Peak Velocity-Related Acceleration for the Project's location is 0.128

1.4 PROJECT CONDITIONS

A. Field Measurements
1. Take field measurements to verify or supplement dimensions indicated. Be responsible for accurate fit of the Work.
2. Verify that all equipment in this section is coordinated to provide a complete working process and system integration

B. Utilities Verification
1. Utilities and connections may vary between approved manufacturers.
2. All utilities for these items are indicated in mechanical and electrical documents and are referenced in Divisions 15 and 16 / 21 through 28. Any deviations from these utilities must be documented within bid and shop drawing submittals.

1.5 ACTION SUBMITTALS

A. Product Data: Submit complete catalogue data, including a chart of manufacturer's standard finishes for all materials, equipment and products for work in this section.

B. Shop Drawings: Submit complete shop fabrication and installation drawings, including scaled plans, elevations, sections, details and schedules. Show relationship to adjoining materials and construction. Shop drawings shall not exceed 11 inches x 17 inches in size.

PART 2 - PRODUCTS

2.1 TABLE-BASED BENCHES

A. Modular System Description
1. Made of tubular style framing combined with oval formed steel upright.
2. To be used in island, wall or peninsula situations.
3. Tubular Frames: Table and shelves supports.
4. Table supports to be adjustable height in 2" increments.
5. Table support frames to have levelers equipped.
6. Provide a movable cabinet stop rail underneath the back of the table.
7. Integral rear and tubular frame to be used for carrying services and electrical conduit.
8. Rear upright supports to be equipped with slots for adjustable shelving and levelers.
9. All services must terminate at the top of the rear tubular support frame.
10. Assembled frame to be self supporting without needing to be anchored to the building.
11. The modular system must ship complete from the factory with minimal on-site assembly.

B. Wall Series Rear Support Structure:
1. Nominal table frame dimensions:
   a. Width: 48", 60"
   b. Depth: 2"
   c. Height: 84"
2. Rear and Center Uprights:
   a. 2" outside diameter 11ga. Painted or Stainless Steel
   b. Center uprights apply to units 60", 72" or 96" wide to accommodate split shelving.
   c. Stainless steel 3/8" x 2-½" long levelers.
3. Upper and Lower Cross Rails:
   a. 11ga. Painted Steel

4. Load Capacity: Rear Upright to support up to 3 shelves loaded to a maximum of 180lbs per 12” deep shelf. The total load capacity for the Rear Upright is 540lbs.
5. Uprights to house services, electrical and data cables.
6. High/low voltage cabling to be in a separate upright from gas piping.
7. Lower cross rail shall house an electrical circuit raceway.
8. Rear posts have slots punched on 1” increments starting at nominal 59” above the finished floor, to the top of the post.

C. Island Series Rear Support Structure:
1. Nominal table frame dimensions:
   a. Width: 48”, 60”
   b. Depth: 6”
   c. Height: 84”
2. Rear and Center Uprights:
   a. 2” x 6” 14ga. Painted or Stainless Steel
   b. Removable end panels shall be ordered separately.
   c. Center uprights apply to units 60”, 72” or 96” wide to accommodate split shelving.
   d. Stainless steel 3/8” x 2-½” long levelers.
3. Upper and Lower Cross Rails:
   a. 11ga. Painted Steel
   b. Load Capacity: Rear Upright to support up to 3 shelves loaded to a maximum of 180lbs per 12” deep shelf. The total load capacity for a single sided Rear Upright is 540lbs. The total load capacity for a double sided Rear Upright is 1080lbs.
   c. Uprights to house services, electrical and data cables.
   d. High/low voltage cabling to be in a separate upright from gas piping.
   e. Lower cross rail shall house an electrical circuit raceway.
   f. Rear posts have slots punched on 1” increments starting at nominal 59” above the finished floor, to the top of the post.
4. Tubular Table Assembly:
   a. Nominal table assembly dimensions:
      1) Width: 48”, 60”, 72”, 96”
      2) Depth: 29” or 35”
      3) Height: Adjustable from 31” – 37” (not including work surface)
   b. Tubular Table Legs:
      1) 2” outside diameter, 11ga. Painted or stainless steel outer leg
      2) 1-¾” outside diameter, 11ga. Painted or stainless steel inner telescoping leg
      3) Stainless steel clad 1-½” diameter round adjustable leveling toe.
   c. Capable of vertical height adjustment in 2” increments.
   d. Table assembly shall be fastened to the rear upright with two (2) hex 5/16” socket head bolts
   e. Leveling Bolt: Frame shall be fitted with a leveling bolt which will allow the legs to be adjusted for proper alignment of work surface height.
   f. Load Capacity: Table frame shall support the work surface plus 100lbs/linear ft of table length up to a maximum load rating of 800lbs.

D. Compressed Air and Vacuum Fixtures:
1. Rear upright structure to support a maximum of three plumbing fixtures.
2. Fixtures shall be Needle Valve style with a single serrated hose end.
3. Plumbing lines shall be pre-piped ¼” copper tubing running the length of the upright.
4. All burning gas tubing shall be specified as stainless steel.
5. All plumbing shall have quick disconnect at the top of the upright.
6. Coil type hose
7. Plumbing shall be arranged in such a fashion that the services cannot be intermixed.

8. All service valves and quick disconnects shall be keyed and color-coded. Only plug and body connects of the same key will couple and allow flow.
9. Provide white opaque coiled hose connectors between top of table upright to ceiling service panel with quick disconnects at both ends. Length extending approximately 3' for flat ceiling areas and approximately 5' for sloped ceiling areas above the top of the upright. No excess cord allowed, field verify condition if necessary.

E. Service Connections:
1. Electrical, Data and Plumbing services shall terminate at the top of the rear support upright.
2. Electrical services consist of:
   a. Island Series Table: five, 20 amp circuits per double-sided table, with 3 - 20 amp cord extending approximately 3' for flat ceiling areas and approximately 5' for sloped ceiling areas above the top of the upright. (See diagram for outlet configuration and conductor sizes)
   b. Wall Series table: Three, 20 amp circuits per double-sided table, with 2 - 20 amp cord extending approximately 3' for flat ceiling areas and approximately 5' for sloped ceiling areas above the top of the upright. (See diagram for outlet configuration and conductor sizes)
   c. 2500 watts continuous duty power cord for plug connection to overhead ceiling service panel
3. Provide pre-wired power raceway, integral in lower cross rail, to run full width of table-based bench assemblies. Include the following features:
   a. Power strip with one, 20 amp branch circuit with 120 volt receptacles equally spaced at no more than 18" apart.
   b. One 20 amp dedicated branch circuit, with 120 volt receptacle at one side of integral raceway.
4. Provide one additional 20 amp.120 volt receptacle at one rear support upright.
5. Refer to Specification Section 26 27 26 "Wiring Devices" for receptacle type and color.
6. Data services shall have a male plug extending approximately 6' above the top of the upright.
   a. Provide Hubbell PCX5EB15, 20 foot patch cord. Coil excess cable neatly above bench.
      1) Factory assembled patch cords with ends attached (from Hubbell) must be capable of being routed through furniture raceway.
   b. Provide Hubbell SFC5EB pass through coupler and FP2BK furniture plate.
      1) If pass through coupler and furniture plate differ from specifications they must be approved by Owner before acceptance.
7. Bench assembly to be UL approved.

F. Ceiling Service Panels:
1. Panels shall be compatible with most T-grid acoustical suspended ceiling structures.
2. Panel shall provide a means to mount and disconnect quick connect service fixtures, electrical and data outlets.
3. Panel shall accommodate single sided and back to back bench configurations.
4. Panels ship with electrical outlets, service fixtures, junction boxes and cover plates. Junction boxes are to be provided by the casework manufacturer.
   a. See diagram for junction box sizes and outlet configuration.
5. Panels shall be:
   a. 18 gauge cold rolled steel with a powder coated finish.
   b. Sizes:
      1) For Island Series Rear Support Structures: See Drawings for dimensions
      2) For Wall Series Rear Support Structures: See Drawings for dimensions
6. Provide cross framing and reinforcing as required for support.

G. Ceiling Service Carrier:
1. Basis of Design: Hamilton Lab, Nautilus
2. Carriers shall provide a means to mount and disconnect quick connect service fixtures, electrical and data outlets.

3. Carriers ship with electrical outlets, service fixtures, junction boxes and cover plates. Junction boxes are to be provided by the casework manufacturer.
4. Carriers shall be:
   a. 18 guage cold rolled steel with a powder coated finish.
   b. Size as indicated on drawings

H. Removable Service Columns
1. Columns shall be:
   a. 18 gauge cold rolled steel with a powder coated finish.
   b. Size as indicated on drawings
2. Column shall provide a means to mount and disconnect quick connect service fixtures, electrical and data outlets.
3. Column ship with electrical outlets, service fixtures, junction boxes and cover plates. Junction boxes are to be provided by the casework manufacturer.

I. Shelves:
1. Nominal shelf dimensions:
   a. Width: 30 inches, 36 inches, 48 inches.
   b. Depth and weight capacity: 6-, 8- or 12-inch; 18-inch; 130 lb; 24-inch; 100 lb.
   c. Thickness: 1 inch.
2. Shelf requirements:
   a. Shelves shall be laminated safety glass shelf with powder coated cold rolled steel frame, capable of being locked into position.
   b. Shelves, hat channel supports and separate shelf lip: 18 gage cold-rolled steel.
   c. Shelves shall have a 1 inch overhang behind the face of the rear tubular posts.
   d. Shelf brackets rise above the shelf surface to provide sides to be constructed of 11ga. powder coated cold rolled steel or stainless steel.
   e. Shelves shall have a rear 1 inch high retaining lip. Top shelf assemblies do not require retaining lip
   f. Vertical shelf adjustment in 1 inch increments
   g. 1 inch tall x 5/16 inch dia. shelf retainer rods, available in #304 stainless steel or #304 powder coated stainless steel.

J. Paint Color: To match Thermo Fisher PW Petal White 1362

2.2 MOBILE STORAGE UNITS (MOBILE BASE CABINETS)

A. General
1. Nominal dimensions: 27 13/16 inch height without add-a-drawer, 21-5/8 inch deep, widths as indicated,
2. Inset steel construction body with wood door and drawer fronts. Exterior members in same plane without overlap.
3. Steel cabinets with heavy-duty 3 inch rubber single-wheel casters with locks and foot brakes.
4. Steel, chemical resistant high-pressure laminate faced, removable extended work surface capable of being reinserted at top of cabinet or add-a-drawer unit. The ability of the work surface to be removable and reinserted at the top of cabinet or add-a-drawer unit is as applies to the manufacturer. Chemical resistant plastic laminate color to match Nevamar S6054T Wrought Iron, Textured Finish for Durcon Graphite molded resin tops or Pionite SG228 Slate, Suede Finish for Epoxyn Products Dark Khaki #20 molded resin tops.
5. Each cabinet equipped with anti-tipping counterweight.
6. Removable add-a-drawer feature on drawer and cabinet units as shown in drawings.
7. Retracting grab bar handle
8. Drawers with integral locking device.

9. Door cabinets with adjustable split depth shelf.
10. Paint color:

2.3 HEAVY DUTY MOVEABLE TABLES

A. General
1. Nominal dimensions: as indicated.
2. Work surface support frame: 11 gage cold-rolled steel tubing. Cabinet support channels: 14 gage cold-rolled steel. Weld members using the inert gas process.
3. Support arms: 11 gage cold-rolled steel.
4. End caps: Flame resistant ABS plastic, color matched.

B. Four-Leg Adjustable-Height Table (Heavy Duty Mobile Table)

C. Freestanding table capable of supporting suspended base cabinets

2.4 METAL FINISH

A. After fabrication and before finishing, clean and treat sheet steel to prevent corrosion and to provide proper bond of the finish.

B. Apply a prime coat baked on and sanded smooth and a synthetic enamel or resin base finish system baked on. Provide a finish for surfaces exposed to view on exterior and interior of cabinets which complies with performance requirements for moisture and chemical resistance specified in Section 12305 and is smooth, semi-matte finish, evenly covered without short or thin coating on corners, runs, sags, or roughness.
1. Color: as indicated on each section above.

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to Section 12 31 00.

END OF SECTION

SECTION 12 31 04

METAL LABORATORY CASEWORK

PART 1 - GENERAL

1.1 SUMMARY

A. SECTION INCLUDES:
1. Base Cabinets and Suspended Cabinets
2. Sink Cabinets
3. Acid Storage Cabinets
4. Flammable Storage Cabinets
5. Full Height Cabinets

1.2 RELATED DOCUMENTS

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

B. Section 12 31 00 – General Requirements for Casework and Fume Hoods

C. Section 12 31 01 – High Performance Laboratory Fume Hoods

1.3 REFERENCES

A. Scientific Equipment and Furniture Association 2008, Third Edition, (SEFA)
1. Laboratory Furniture, Casework, Shelving and Tables.
2. Installation of Scientific Laboratory Furniture and Equipment.

B. National Fire Protection Association (NFPA)
1. 30 - Flammable and Combustible Liquids Code, 2008 Edition.

1.4 PROJECT CONDITIONS

A. Field Measurements
1. Take field measurements to verify or supplement dimensions indicated. Be responsible for accurate fit of the Work.

1.5 ACTION SUBMITTALS

A. Product Data: Submit complete catalogue data, including a chart of manufacturer's standard finishes for all materials, equipment and products for work in this section.

B. Shop Drawings: Submit complete shop fabrication and installation drawings, including scaled plans, elevations, sections, details and schedules. Show relationship to adjoining materials and construction. Shop drawings shall not exceed 11 inches x 17 inches in size.

PART 2 - PRODUCTS

2.1 TYPE AND MANUFACTURERS

A. Inset Steel construction with doors, drawers and exterior members in same plane without overlap.

B. For approved manufacturers see Spec Section 12 31 00.

2.2 METAL CABINET CONSTRUCTION

A. General
1. Include completely enclosed vertical posts. Include the items of cabinet construction listed. Exclude provisions for doors in open shelf cabinets.
2. Lab Casework in room L047 is part of Alternate No. A-5

B. Base Cabinets and Suspended Cabinets
1. Front horizontal rail offset to form rebate for door and flanged down not less than one-inch.
2. Intermediate horizontal rails between drawers to be locked, and with security panel if locks are keyed differently.
3. Completely enclosed toe space.
4. Lower corner reinforcing gusset with 3 inch high leveling bolts for each corner.
5. Sides or end panels die-formed with deep, channel-shaped, corner posts at the front and flanged at top, bottom and back; exposed face of corner posts and stiles not less than 1 inch wide and flanged inward to form a rebate for drawers and doors.
6. Back consisting of top and bottom rail channel formed and welded to back flange of side, with space between left open for access to utility lines; access space of cupboard units closed with removable backs.
7. Cutouts, if required, for service fixtures for fume hoods.
8. One adjustable shelf per cupboard unit, adjustable on 1/2 inch to 1-1/16 inch centers, edges formed down 3/4 inch and back into channel shape; split-depth so that front section can be removed to allow for taller storage.
9. Full-length hinge reinforcement concealed in corner posts.
10. Recessed adjusting bolt access hole with removable cover.
11. Slots for addition of case channels and notches for addition of intermediate horizontal rails.
12. Removable, die-formed case channel with hardened steel, cadmium-plated ball-bearing roller for drawers.
13. Provide security panels between locked drawers.

C. Sink Cabinets
1. Front horizontal rail offset to form rebate for door and flanged down not less than one-inch.
2. Completely enclosed toe space.
3. Lower corner reinforcing gusset with 3 inch high leveling bolts for each corner.
4. Sides or end panels die-formed with deep, channel-shaped, corner posts at the front and flanged at top, bottom and back; exposed face of corner posts and stiles not less than 1 inch wide and flanged inward to form a rebate for drawers and doors.
5. Back consisting of top and bottom rail channel formed and welded to back flange of side, with space between left open for access to utility lines; access space of cupboard units closed with removable backs.
6. Cutouts, as required, for sink and service fixtures.
7. Full-length hinge reinforcement concealed in corner posts.
8. Recessed adjusting bolt access hole with removable cover

D. Acid Storage Cabinets
1. Refer to drawings for location and dimensional information
2. Designed for the storage of harsh acids and corrosive chemicals, Factory Mutual approved.
3. Fully line interior of cabinet, including doors, with polyethylene liner. Provide coved corners and 1-inch lip at the bottom front of the cabinet opening to contain spills.
4. Provide lock and half-depth coated heavy-duty shelf.
5. Non-removable and conspicuous label: ACID.
6. Provide vent port at rear of cabinet for venting of fumes.
7. Provide PVC or polypropylene vent assembly for house exhaust connection at back of cabinet in pipe chase.

E. Flammable Storage Cabinets
1. Refer to drawings for location and dimensional information
2. Designed for the storage of flammable and combustible liquids and to comply with NFPA 30. Factory Mutual approved and UL listed.
3. Bottom, top, sides, and doors fabricated of minimum 18 gage steel, double-walled with a 1-1/2 inch air space between walls, all joints welded or screwed to provide rigid enclosure.
4. Doors: self-closing with fusible link hold open feature and door synchronizer.
5. Doors fitted with piano hinges, 3-point latching device in right-hand door, and full height astragal on left-hand door. Include lock.
6. 2 inch deep liquid tight pan to cover entire bottom of cabinet.
7. Heavy duty shelves, reinforced at all edges and at center underside.
8. Vent ports with built-in flash arrestors of perforated steel.
9. Non-removable conspicuous warning Label: FLAMMABLE KEEP FIRE AWAY.
10. Flammable storage base cabinets to include:
    a. One full depth shelf.
    b. Dual vent ports at rear of cabinet with top and bottom positions.
    c. Provide PVC or polypropylene dual ganged vent assembly for house exhaust connection at back of cabinet in pipe chase.

F. Full Height Cabinets
1. One-piece cabinet top and front horizontal rail with offset for door recess, flanged and welded to back.
2. Fixed interior cabinet bottom.
3. Rear corner reinforcing gusset.
4. End panels formed as specified for base cabinets, with full-length hinge reinforcement.
5. Extruded aluminum overhead track and nylon bottom guides for framed sliding doors, with track mounted to track support welded to cabinet top.
6. Five, full-width adjustable shelves.
    a. Frame for glazed doors: double wall construction, 5/8 inch minimum thickness; outer face with corners mitered, welded and ground smooth; inner face mitered corners and fastened to outer face with sheet metal screws; frames shall be fitted with rubber bumpers; glass set in extruded rubber glazing channels, continuous in one piece with one joint.

G. Finish
1. After fabrication and before finishing, clean and treat sheet steel to prevent corrosion and to provide proper bond of the finish.
2. Apply a prime coat baked on and sanded smooth and a synthetic enamel or resin base finish system baked on. Provide a finish for surfaces exposed to view on exterior and interior of cabinets which complies with performance requirements for moisture and chemical resistance and is smooth, semi-matte finish, evenly covered without short or thin coating on corners, runs, sags, or roughness.
3. Color: White.

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to Section 12 31 00.

END OF SECTION

SECTION 12 36 61

SIMULATED STONE COUNTERTOPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Solid-surface-material countertops and backsplashes.

B. Related Sections:
1. Division 06 section “Wood Veneer Faced Architectural Cabinets” for cabinets receiving counter tops.
2. Division 06 section “Plastic Laminate Faced Architectural Cabinets” for cabinets receiving counter tops.

1.3 ACTION SUBMITTALS

A. Product Data: For countertop materials.

B. LEED Submittals:
1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
   a. Include statement indicating cost for each product having recycled content.
2. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
3. Certificates for Credit MR 7: Chain-of-custody certificates indicating that products specified to be made from certified wood comply with forest certification and chain-of-custody requirements. Include statement indicating cost for each certified wood product.
4. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
5. Product Data for Credit IEQ 4.4: For adhesives and composite wood products, documentation indicating that products contain no urea formaldehyde.

C. Shop Drawings: For countertops. Show materials, finishes, edge and backsplash profiles, methods of joining, and cutouts for plumbing fixtures.

D. Samples for Initial Selection: For each type of material exposed to view.

E. Samples for Verification: For the following products:
1. Countertop material, 6 inches square.
2. Wood trim, 8 inches long.
3. One full-size solid-surface-material countertop, with front edge and backsplash, 8 by 10 inches, of construction and in configuration specified.

1.4 PROJECT CONDITIONS

A. Field Measurements: Verify dimensions of countertops by field measurements after base cabinets are installed but before countertop fabrication is complete.

1.5 COORDINATION

A. Coordinate locations of utilities that will penetrate countertops or backsplashes.

PART 2 - PRODUCTS

2.1 SOLID-SURFACE-MATERIAL COUNTERTOPS

A. Configuration: Provide countertops with the following front and backsplash style:
1. Front: Straight, slightly eased at top.
2. Backsplash: Straight, slightly eased at corner.
3. Endsplash: Matching backsplash.

B. Countertops: 3/4-inch- thick, solid surface material with front edge built up with same material.

C. Backsplashes: 3/4-inch- thick, solid surface material.

D. Fabrication: Fabricate tops in one piece with shop-applied edges and backsplashes unless otherwise indicated. Comply with solid-surface-material manufacturer's written instructions for adhesives, sealers, fabrication, and finishing.
1. Fabricate with loose backsplashes for field assembly.

2.2 COUNTERTOP MATERIALS

A. Composite Wood and Agrifiber Products: Provide products that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Particleboard: ANSI A208.1, Grade M-2-Exterior Glue , made with binder containing no urea formaldehyde.

C. Plywood: Exterior softwood plywood complying with DOC PS 1, Grade C-C Plugged, touch sanded.

D. Solid Surface Material: Homogeneous solid sheets of filled plastic resin complying with ANSI SS1.
1. Basis-of-Design Product: Subject to compliance with requirements, provide LG Chemical LTD or comparable product by one of the following:
a. Avonite Surfaces.
b. E. I. du Pont de Nemours and Company.
c. Formica Corporation.
d. Samsung Chemical USA, Inc.
e. Wilsonart International.
2. Integral Sink Bowls: Comply with ISSFA-2 and ANSI Z124.3, Type 5 or Type 6, without a precoated finish.
3. Colors and Patterns: Refer to Finish Schedule on Drawings for solid surface countertop types SS-1 and SS-2.

E. Recycled glass and concrete composite resurfacing as manufactured by Icestone (Type ST-4).
1. Refer to Finish Schedule on Drawings for project location and vendor contact.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install countertops level to a tolerance of 1/8 inch in 8 feet.

B. Fasten countertops by screwing through corner blocks of base units into underside of countertop. Pre-drill holes for screws as recommended by manufacturer. Align adjacent surfaces and, using adhesive in color to match countertop, form seams to comply with manufacturer's written instructions. Carefully dress joints smooth, remove surface scratches, and clean entire surface.
   1. Install backsplashes and endsplashes to comply with manufacturer's written instructions for adhesives, sealers, fabrication, and finishing.
   2. Seal edges of cutouts in particleboard subtops by saturating with varnish.

END OF SECTION

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SECTION 12 93 10

SITE FURNISHINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Standard Waste Receptacle.
2. Recycling Waste Receptacle.
3. Bench.
4. Bike Loops.
5. Picnic Table.
6. Ash Urn.

B. Site Furnishings listed above will be bid, procured, and installed under the FF&E contract by the FF&E contractor.

1.3 SUBMITTALS

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

B. Finish colors, for selection, from manufacturer's standard colors and finishes.

C. Product Schedule: For site furnishings. Use same designations indicated on Drawings.

D. LEED Submittals
1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
   a. Include statement indicating cost for each product having recycled content.
2. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.

E. Material Certificates: For site furnishings, signed by manufacturers.

F. Maintenance Data: For site furnishings to include in maintenance manuals.

G. Shop Drawings: Provide Shop Drawings for review on all custom site furnishings.

1.4 WARRANTY

A. Products shall be free from defects in material and/or workmanship for a period of three years from the date of invoice.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of site furnishing(s) through one source from a single manufacturer.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel: Free of surface blemishes and complying with the following:

1. Plates, Shapes, and Bars: ASTM A 36/A 36M.

B. Anchors, Fasteners, Fittings, and Hardware: Manufacturer's standard

C. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107; recommended in writing by manufacturer, for exterior applications.

D. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound; resistant to erosion from water exposure without needing protection by a sealer or waterproof coating; recommended in writing by manufacturer, for exterior applications.

2.2 WASTE RECEPTACLES, STANDARD AND RECYCLING

A. Double Unit: Composed of Standard and Recycling receptacles. Model: ‘Select Recycling Systems’ by Landscapeforms, perforated steel, silver pangaard color, black powdercoat trim and sign plate.

B. Size: 17” x 34” x 42”.

C. Standard Waste Receptacle Size: 25 gallon, front opening door, multi-use opening.

D. Recycling Waste Receptacle Size: 25 gallon, front opening door, 5” diameter opening.

E. Installation Method: Surface mount. Locate per drawings.

F. Color and Finish: Selected from manufacturer's standard colors. Powdercoat or Pangaard standard manufacturer's finish.

G. Recycling sign decals: Two standard wording sign plates for 'waste' or 'recycle'.

H. Insert: Black poly liner.

I. Locking Hardware: With 2 extra sets of keys.

2.3 BENCH

A. 'Geometric Series' by Victor Stanley in nominal lengths in custom layout and configuration as noted in plans. Local Rep: Howard White and Associates, 877-870-7745.

B. Material: Ipe bench top and silver powdercoat steel frame.

C. Mounting: Surface mount.

D. Contractor to submit Shop Drawings for review by Owner's representative prior to custom fabrication.

2.4 BIKE LOOPS

A. 'Ride' by Landscapeforms Metro 40 line, cast aluminum, silver pangaard II color.

B. Surface Mount per manufacturer's method and including manufacturer's hardware.

2.5 PICNIC TABLE

A. Select from one of the following manufacturers:

B. Model MLPT212W Cluster Seating Picnic Table by Maglin, 1-800-716-5506, , 70" length x 67" width x 29" height, square steel tube frame, E-coat Rust Proofing and powdercoat gray or silver.
   1. Material (table top and bench seat): ipe (with penetrating sealer)

C. Model PT-2 Parsons Series Picnic Table by Victor Stanley, Inc., Local Rep: Howard White and Associates, 877-870-7745, 6' length, shot blasted steel tubular frame, powdercoat TGIC color silver.
   1. Material (table top and bench seat): Mahogany

2.6 ASH URN

A. 'Humo' by Santa and Cole. Stainless Steel, brushed finish. Surface mount.

2.7 FABRICATION

A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.

B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.

C. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.

D. Factory Assembly: Assemble components in the factory to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

2.8 FINISHES, GENERAL

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

B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance.

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

3.2 INSTALLATION, GENERAL

A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.

B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.

C. Installation of site furnishings shall be coordinated with the installation of the poured in place resilient playground surfacing and associated base material.

3.3 CLEANING

A. After completing site furnishings installation, inspect components. Remove spots, dirt, and debris. Repair damaged finishes to match original finish or replace component.

END OF SECTION

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SECTION 13 03 40

CONTROLLED ENVIRONMENT ROOMS

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PART 1 - GENERAL

1.1 REFERENCES

A. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)

1. HVAC Fundamentals Handbook.

B. American Society for Testing and Materials (ASTM)

1. A167 - Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
2. A653/A653M - Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
3. B209 - Specification for Aluminum and Aluminum-Alloy Sheet and Plate
4. B209M - Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric].
5. C920 - Specification for Elastomeric Joint Sealants.

C. National Fire Protection Association (NFPA)

1. 70 - National Electrical Code. (NEC)

1.2 SYSTEM DESCRIPTION

A. Unit shall be prefabricated and of all modular construction. Each room shall be furnished and installed as a complete self-contained system with all essential components, controls and equipment necessary to reach the environmental conditions specified.

B. Temperature

1. Temperature range, except during defrost cycles, as follows:
   a. Cold working labs (Type 1): 4 degrees C. constant.
   b. Storage rooms (Type 2):
      1) Cold storage room 2A: 4 degrees C. constant.
      2) Warm storage room 2B: 16 degrees C. constant
      3) Warm storage room 2C: 24 degrees C. constant

2. Temperature control:
   a. Cold working labs and Storage Room (Type 1 and Type 2A): plus-or-minus 1.0 degrees C.
   b. Warm storage rooms (Type 2): plus-or-minus 1.0 degrees C.

3. Manufacturer to minimize temperature offset measured at the evaporator during defrost cycles.

C. Humidity

1. Relative humidity for all cold rooms shall not to exceed 75 percent.
2. Relative humidity for all warm storage rooms shall be 25%, plus-or-minus 10% RH, year around.

D. Temperature Uniformity

1. Temperature shall be provided and controlled as specified above. Temperature ranges shall be provided with uniformity throughout the entire room to within 2 degrees C as measured by a multi-point strip chart recorder using a minimum of 9 selected thermocouple locations during a 24-hour period. Test locations include geometric center of room and all corners 12 inches away from walls and ceiling down to 36 inches above finish floor.

E. Thermal Loads: Provide each room capability of maintaining indicated controlled temperature and humidity conditions when operating under the following thermal loads:

1. Door Openings: Maximum of 8 per hour, for 8 working hours per day.
   a. Recovery time for a 5 second door open condition shall not exceed 5 minutes.
2. Number of Occupants: 1 person 8 hours per day (Cold Working Labs).
3. Number of Occupants: 1 person 4 hours per day (Cold and Warm Storage Rooms).
4. Lighting as indicated in this Section.
5. Owner's Equipment: Minimum load is a continuous zero-load condition to 2 kilowatts operating 24 hours per day.
6. Ambient Conditions Exterior to Room: 60 to 80 degrees F., 25-60% RH.

F. Ventilation and Exhaust

1. Each room will receive 25 CFM of conditioned air from the building system. Temperatures supplied will be 13°C (55° ±5°F) with relative humidity variable within the range of 30-99% R.H.
2. Design units to provide temperature levels indicated with this conditioned air being continuously supplied to the room.
3. Ventilation air shall be supplied directly to the evaporator inlet.
4. Return air shall be exhausted via hard-duct connection to the building exhaust system.

G. Air Circulation

1. Uniformly distribute and continuously re-circulate room air through a ceiling mounted plenum.

H. Sound Level

1. Maximum ambient background sound level within each room: NC-55 at full air velocity as defined by the ASHRAE Fundamentals Handbook.

I.Testing

1. Completely assemble and test all the rooms after installation.
2. Include complete checkout of mechanical equipment, function check, uniformity and control check and calibration at various temperatures.
3. Provide test reports certified by independent testing agency.

1.3 SUBMITTALS

A. Warranty

1. Submit Statements of Compliance for the following:
   a. Panel materials and construction.
   b. Joint materials.
   c. Performance requirements.

B. Special Warranties

1. Submit Special Warranties for products so specified.

C. Test Reports

1. Submit certified test reports to the Architect for approval after installation of assembled and completed rooms.
   a. Temperature range and control.
   b. Air circulation distribution and control.
   c. Floor loading.
   d. Illumination distribution, control and intensity.
   e. Sound level ratings.

D. Shop Drawings

1. Submit Shop Drawings showing room layout, elevations and details of fabrication, installation and connection to utilities including routing to drain for evaporate condensate piping.
2. Include in the shop drawings all building ductwork and piping above the chambers to demonstrate coordinated location of all above chamber components with the building systems.
3. All wiring devices, switches, occupancy sensors and fire alarm devices within Environmental Room.

E. Maintenance Instructions

1. Submit maintenance instructions for finished materials and operating and maintenance instructions for equipment.

F. Bid Submittal

1. Include with bid submittal the proposed temperature offset measured at the evaporator during the defrost cycles for Architect’s review prior to award.

1.4 QUALITY ASSURANCE

A. Contractor's Qualifications

1. Employ the manufacturer or his authorized representative to install the Work using workmen skilled in the trade. If requested by the Architect, submit evidence of the installer's experience, including a list of projects for which work similar in scope and quality to that specified herein was installed.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protection

1. Protect the Work from damage during transportation to the site, storage at site and during progress of Work until completion.

1.6 PROJECT CONDITIONS

A. Field Measurements

1. Take field measurements to verify or supplement dimensions indicated. Be responsible for accurate fit of the rooms with the building constraints and utility distribution. Verify service and maintenance access for all support equipment. Coordinate the work with the requirements of the drawings including all required electrical clearances.

1.7 WARRANTY

A. Special Warranties

1. Compressors shall be warranted for 5 years.
2. Electronic controllers shall be warranted for 3 years.
3. Room panels and hardware shall be warranted for 10 years against deformation due to temperature and humidity conditions.

1.8 MAINTENANCE

A. Maintenance Contract

1. Provide maintenance required with yearly cost breakdown over 5 years. If maintenance is provided by other than manufacturer, furnish name of maintenance contractor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Models of the following manufacturers are acceptable provided they meet the criteria of these specifications:

1. Harris Environmental Systems, Inc.
2. Frost Environmental Rooms
3. Norlake Scientific

2.2 MATERIALS

A. Panel Materials

1. Aluminum sheet: ASTM B209.
2. Galvanized steel sheet: ASTM A653/A653M, commercial quality, coating designation G90.
3. Insulation: foamed-in-place urethane.
4. Stainless steel sheet: ASTM A167.

B. Joint Materials

1. Gaskets: extruded vinyl or neoprene, 3 mm (1/8 inch) minimum thickness.
2. Sealant: ASTM C920, Type M, Grade NS, Class 25.

C. Framing Members

1. Non-metallic, non-organic, non-hygroscopic, odorless, vermin proof, incombustible and resistant to deterioration due to high temperature or humidity.

D. Fasteners

1. Screws and other fasteners exposed on the inside of room: stainless steel or aluminum.

2.3 ROOM CONSTRUCTION

A. General

1. Assemble rooms in prefabricated sections consisting of wall, floor and roof panels mechanically locked together or to framing members without exposed fasteners, with joints sealed with gaskets or sealant. Fabricate sections so as to prevent metal-to-metal contact between inner and outer surfaces and with the surfaces flush, without batten strips or pressure clips.

B. Sizes: Interior Dimensions of Rooms

Room No.	Type	Width	Depth	Condenser Location
L003	2A	9’-4”	10’-3”	L002B
L004	2B	10’-1”	9’-1”	L002B
L005	2C	10’-0”	9’-1”	L002B
L011	1	10’-3”	9’-8”	L002B
L045	1	9’-4”	9’-8”	L001
Xxx*	1	9’-4”	9’-8”	L001

*See Enhanced Scope

1. Height:

a. 8’-6” minimum inside clearance to the underside of the ceiling panels.
b. 9’-2” minimum nominal overall exterior height of room including floor and roof panels.

C. Panel Construction

1. Wall and roof panels: inner and outer face sheets bonded to insulation core.
2. 4-inch maximum thickness for all panel construction including walls, floor, and roof.
3. Exposed face sheets: one of the following:

a. 16 B & S gage aluminum sheet.
b. 0.76-mm (0.030-inch) embossed aluminum sheet.
c. 0.48-mm (0.019-inch) aluminum sheet bonded to exterior grade fir plywood.
d. 1.01-mm (20 USS gage) galvanized steel sheet.

D. Accessories

1. Provide vapor seal access ports for penetrating services as small as possible, recessed flush with inner face sheets, without exposed fasteners. Seal sleeves with sealant.
2. Provide metal filler panels to close gap between panels and building construction and present a neat finished installation. Provide metal fillers flush with control console to finished ceiling to conceal conduits.
3. Provide metal filler panels to enclose space above rooms which is not enclosed by adjacent wall construction. Provide access panels in such filler panels as required for maintenance of equipment. Fabricate filler panels of face sheets specified for panel construction with internal stiffeners as required to prevent visible distortion of panels.

4. Provide two 75-mm (3-inch) -round duct connection collars, one for ventilation air and one for exhaust air for all rooms.
5. Provide galvanized single or double tiered steel rack assemblies to support condensing units and all related components.
6. Provide remote, floor mounted rack for condenser mounting. See drawings for location.

2.4 ROOM FINISHES

A. Floors

1. Cover floor panels with 5-mm-thick (3/16-inch-thick) neoprene matting with ribbed non-skid surface.

B. Wall and Roof Panels

1. Exposed metal surfaces, including underside of steel roof panels: thoroughly cleaned, primed and factory finished with baked-on enamel system in manufacturer's standard white color, unless otherwise specified. Enamel for interior surfaces of walls and plenum: epoxy, polyester or modified acrylic, white color. Minimum dry film thickness of enamel: 38 microns (1.5 mils).

C. Floor Panels

1. Construction similar to wall and roof panels.
2. Fabricate floor to support a uniformly distributed live load of 300 psf.

D. Ceiling

1. Non-metallic, translucent, washable egg-crate acrylic panels unless indicated otherwise.
2. 2 foot by 2 foot, lay-in prismatic Lexan tiles for Warm Rooms.

E. Ramp

1. None required, rooms shall be recessed.

2.5 DOORS

A. Construction

1. Insulated panel construction same as walls, flush and centered in a wall panel, hinged as indicated Minimum door opening: 860 mm (34 inches) x 1980 mm (78 inches).
2. Provide anti-condensate electric heater/wires concealed on door and behind jambs on all sides to eliminate condensation and frost.
3. Fitted with insulating glass window consisting of 3 easily removable and heated panes with sealed air spaces in between:
   a. Full glass with 3” frame
4. Sealed with neoprene gaskets with magnetic steel core or extruded vinyl gaskets and adjustable wiper at bottom.

B. Hardware

1. Provide the following for each door:
   a. Manufacturer's standard self-closing hinges.
   b. One break-away latch with cylinder lock and inside safety release handle.
2. Hardware exposed to view: chromium-plated brass, unless otherwise specified.

2.6 ELECTRICAL

A. General

1. Provide factory installed conduit, wiring, switches, receptacles, lighting fixtures, fittings and connections for each electrically powered accessory and item of equipment required by provisions of

this section. Provide interconnection of mechanical equipment power and control including but not limited to remote condensing units and other miscellaneous equipment related to controlled environment rooms.

2. Refer to Division 26 for electrical equipment and requirements.
3. Electrical components: UL-approved, complying with NFPA 70.
   a. Provide 100 ampere, 208/120volt, 3 phase, 4 wire plus ground, 10kAIC power distribution panel with 100 ampere main circuit breaker and branch circuit breakers for lighting, receptacles, controls and support equipment (such as desiccant dryer). Unless noted otherwise in type section below.
   b. Environmental room installer to provide electrical connection from electrical panel to condensing unit (controls wiring only), control panel and desiccant dryer.
   c. Provide concealed 1 ½" conduit from power distribution panel to junction box in accessible location above finished ceiling for single-point connection to building power for power distribution panel.
4. Provide all branch circuit wiring from power distribution panel to devices within chamber. Route branch circuit conduit concealed.

B. Power for Type "1" Rooms (Cold Working Labs) and Type 2A (Cold Storage Room)

1. Room operational electrical requirements:
   a. Condensing Unit – 480 Volts, 3 Phase, 60 Hz., 3 wire, with disconnect.
   b. Control Panel – 208/120 Volts, 3 Phase, 60 Hz, 4 wire plus ground with disconnect.
   c. Desiccant Dryer – 208V, 1 Phase, 60 HZ, with disconnect located at dryer.
2. Additional electrical and telecommunication requirements:
   a. Provide junction box located on top of room for telecommunication services with 1" conduit to each telecommunications raceway outlet as shown on Laboratory drawings and details.
   b. Provide two compartment non-metallic surface raceway with quantities of receptacle outlets and communication outlet cutouts. Receptacle outlets to be located 3-0" o.c. for length of raceway, communication to be located 6'-0" o.c. for length of raceway unless otherwise noted. Provide ¾" conduit form surface raceway to power distribution panel. Maximum of four duplex electrical receptacles per circuit. Maximum of eight conductors and ground per conduit. Minimum wire size #12awg. Each receptacle circuit shall include independent neutral conductor (shared neutral is not permitted).
   c. Refer to Division 26 for conduits, fittings and box requirements.

C. Power for Types "2" Rooms (Warm Storage Rooms)

1. Room operational electrical requirements:
   a. Condensing Unit – 480 Volts, 3 Phase, 60 Hz., 3 wire, with disconnect.
   b. Control Panel – 208/120 Volts, 3 Phase, 60 Hz., 4 wire plus ground, 60 Amps with disconnect.
   c. Desiccant Dryer – 208V, 1 Phase, 60 HZ, 4-wire with disconnect located at dryer.
2. Additional electrical and telecommunication requirements:
   a. Provide junction box located on top of room for telecommunication service with 1" conduit to each telecommunications outlet as shown on Laboratory drawings and details.
   b. Refer to Division 26 for conduits, fittings, and box requirements.
3. Provide two compartment non-metallic surface raceway with quantities of receptacles and communication outlets. Receptacle outlets to be located 3-0" o.c. for length of raceway, communication to be located 6'-0" o.c. for length of raceway unless otherwise noted. Provide ¾" conduit from surface raceway to power distribution panel. Maximum of four duplex electrical receptacles per circuit. Maximum of eight conductors and ground per conduit. Minimum wire size #12awg. Each receptacle circuit shall include independent neutral conductor (shared neutral is not permited).

a. Refer to Division 26 for conduits, fittings, and box requirements.

D. Fire Alarm for all Rooms

1. Provide a MD Junction box with conduit exterior of Environment Room Building Fire Alarm in room per Division 26.
2. Provide ¾" C to a junction box above the room.
3. Vendor to install device

E. Lighting

1. Provide lighting fixtures surface mounted to underside of roof panels of each room.
2. Fixtures Types: fluorescent, with T8 (four-foot) lamps, vapor-tight, UL-labeled.
3. Ballasts: electronic, located in the fixture and designated to operate to minus 4 degrees C (40 degrees F).
4. Design lighting to provide light level of 70 foot-candles for "Type 1" rooms and 30 foot-candles for "Type 2" rooms measured at 30 inches above finished floor.
5. Provide emergency lighting battery ballast with characteristics compatible with room temperature.

2.7 AIR CONDITIONING EQUIPMENT

A. Enclosure

1. Enclose air conditioning equipment in a plenum, removable for cleaning and containing a stainless steel or aluminum condensate pan piped to terminal on exterior of room.

B. Heating Elements

1. Aluminum or high grade nichrome coils or finned tubes for low-watt-density and isolated from the working interior to prevent direct radiation.

C. Evaporator Fans

1. Provide fans of capacity to insure uniformity of temperature with a minimum of turbulence, in housing lined with sound-deadening material.
2. Fan motors: minimum, capacitor-start, sealed for-life ball bearing type, externally mounted with direct drive connection to blower or mounted in plenum, with external fusing for over-current and over-temperature protection.
3. Evaporator system shall have a centrifugal-type ceiling fan.
4. Locate evaporator fan at rear wall of rooms to avoid user interference. For Cold Room L011, locate on east wall.
5. Isolate evaporator fans and coils from chamber for vibration control.
6. Rooms to be equipped with redundant (100%) evaporator coils.

D. Refrigeration System

1. Heavy duty type designed to continuously maintain specified temperature in any ambient from 15 to 35 degrees C (60 to 95 degrees F), complete with equipment required, including compressor, condenser, pressure switches, receiver, sight glass, dryer, expansion valves, solenoid valves, automatic capacity by-pass valves when required, magnetic contactor with motor over-load protection, copper-or-aluminum-fin-to-copper-tube evaporator and insulated suction line piping.
2. System must be sized so that the condenser runs continuously and the evaporator unit fan operates on demand. The condenser and related components must be sized to operate under both minimum and maximum loading conditions without "short cycling", excessive wear on the condenser. Units must be designed to operate without excessive noise and without high air velocities within the occupiable space of the room.
3. Pipe condensate from evaporator fan to drain outside of room. See Plumbing drawings for location.

4. Provide flexible suction line and discharge line vibration eliminators.
5. The refrigerant: use manufacturer's standard non-CFC refrigerant for condition of use.
6. Condensing Units Remote Mounted: Factory assembled, using UL listed or recognized components and water-cooled with semi-hermetic serviceable compressor.
7. Do not use cycling solenoid valves for temperature control. Utilize modulating valves to maintain temperature control.
8. High head pressure switch shall be convertible type that can be set for manual or automatic reset at Owner's option. Provide setup as auto reset from the factory.
9. Rooms to be provided with redundant (100%) remote mounted condensing units.

E. Refrigerant Piping

1. Refrigerant piping shall be Type L, hard-drawn seamless copper tubing.
2. All refrigerant suction lines outside of Environmental Room shall be insulated in accordance with Division 15 requirements.
3. All condensate drain lines outside Controlled Environmental Rooms shall be similarly insulated.
4. All suction lines shall be similarly insulated.
5. Each refrigeration system shall include a dehydrator, liquid line sight glass, shut-off valve, liquid line solenoid, thermostatic expansion valve at each evaporator, vibration insulator, and other fittings and accessories as required. Refrigerant lines shall extend vertically from condensing units and concealed above ceiling, then to the evaporators.
6. Refrigerant piping shall be in accordance with manufacturer's instructions and good practice as set forth in ASHRAE Guide and Data Book.
7. Provide separate refrigerant piping system for each of the redundant evaporator/condensing unit systems per room.

2.8 DEFROST AND DEHUMIDIFICATION SYSTEM

A. Provide defrost and dehumidification systems that work in conjunction with the room refrigeration system such that room temperature and product (stored material) temperature is maintained 24 hours per day, 7 days per week and at all times, including defrost periods, desiccant dryer regeneration periods, etc.

B. Defrost timer systems, when used, shall not cause room temperature variations in excess of the performance bands specified during any time they are operating. They shall include early defrost termination controls to end timed defrost as soon as coil ice is cleared. Such timer systems shall be fully adjustable including defrost duration and number of defrosts per 24-hour period. Defrost timer systems shall allow a maximum of 6 defrosts per 24-hour period.

C. Desiccant systems shall be of adequate capacity to eliminate latent loads resulting from the specified door openings, ventilation air rate, and occupants. They shall not cause room temperature variations in excess of the performance bands specified during any time they are operating. Desiccant systems shall reject regeneration heat to the building's exhaust system via an exhaust thimble connection above the desiccant dryer.

D. Provide desiccant dryer to be mounted on top of room for discharge of ventilation-conditioned air into building exhaust system. Locate in area indicated on equipment plans and accessible from adjacent rooms. Coordinate size and location with all Building Systems to obtain required service clearances.

2.9 CONTROLS

A. Provide factory installed control console housing temperature controllers and recorders, alarm controls, and other devices requiring periodic adjustment or user access. Externally mounted, contained in a metal cabinet console with baked enamel finish, with hinged panel enclosing fuses, contactors and connec-

tions, and clear plastic shield for protection of controls. Extend conduit and wiring for service to the power distribution panel to a junction box for connection to electrical service. Provide matching enclosure from top of console to finished ceiling to conceal conduits.

B. Include the following in the console:

1. Provide in the control console a 2-pen temperature recorder to measure room and product temperatures with 7-day chart and cannon pen, 10” diameter circular, Honeywell, or as approved. Provide legible ranges to easily ascertain performance.
2. Main temperature control by calibrated, transistorized solid state unit with bridge-type thermistor sensing, rated control sensitivity of plus-or-minus 0.01 degree C, calibrated dial with set point accuracy of plus-or-minus 1/2 percent of temperature span.
3. Temperature controller: Controller shall provide data collection of room temperature and product temperature history. Controller shall be user configurable and capable of storing up to 7 days of temperature data collected at 5-minute intervals. Collection interval shall be user adjustable. Controller shall include cables, software and any other accessory to allow data to be downloaded to a standard PC and graphed or tabulated. Provide 4-20 MA signal for remote monitoring of room temperature to the Owner’s Building Management System. The sensor that monitors the room temperature to be located at the evaporator coil. The sensor that monitors the product temperature to be located in a non-freezing glycerin solution on a wall at a simulated product location, to ensure product stability during defrost cycles.
4. Automatic switchover controller: Provide programmable automatic controller with manual override to switch over dual support equipment systems at 100% redundant rooms (all type A and B rooms). Dual systems and all associated components to be controlled as two separate systems to backup failure of any single component of either system. During normal operations, each system to automatically switchover every 24 hours to share operational time.
5. Pilot lamps to indicate control action of instruments and interior lights.
6. Dial thermometer connected to remote filled element, accurate to within 1 percent of full scale.
7. Interior light switch for interior lights. (One for each lighting circuit used). Ceiling mounted, dual technology occupancy sensor. (See Electrical Division 26)
8. Automatic defrost by-pass switch.
9. Power distribution panel with main circuit breaker.

C. Alarm System

1. Provide set point deviation alarm.
2. Audible and visible warning device mounted on exterior of room indicating temperature rise or fall outside of design parameters.

D. Remote Monitoring

1. Provide dry contacts (N.C. and N.O.) that actuate under any alarm condition for remote monitoring by Owner’s Building Management System and the Owner’s REES System.

2.10 AVAILABLE BUILDING UTILITIES

A. All utilities for these items are indicated in mechanical and electrical documents and are referenced in Divisions 22 thru 26. Any deviations from these utilities must be documented within bid and shop drawing submittals.

1. Ventilation – 25 cfm supply and exhaust at 1”/-1” wg.
2. Drainage – ¾” condensate pipe to floor drain.
3. Electrical – 208V/120V, 60 Hz, 3-phase, 4-wire plus ground for control panels box at exterior of room. 480V, 60 Hz, 3-Phase, 3-wire for condensing units. See electrical Drawings for available electrical panel locations.
4. R.O. Water – ~~1~~ 1/2” D.I., 1 GPM, 77°F – for the sink located inside the room

5. Process cooling water (primary cooling water source) – 1CHW, 20 GPM max, 42°F entering water temperature minimum
6. Tab water (back-up cooling water source) –1" NP 20 GPM max

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect other construction against damage during progress of the Work.

3.2 COORDINATION

A. The manufacturer to coordinate installation and room requirements due to building limitations and special height restrictions. Support equipment to be accessible for service and maintenance with utility distribution routed accordingly.

3.3 INSTALLATION

A. Include delivery to job site, uncrating, assembly in place and field supervision for final connection. Final connection to mechanical and electrical services is specified in Divisions 15 and 16 and includes the following:

1. Supply and exhaust ductwork.
2. Wiring to junction box.
3. Additional utilities indicated that are not critical to the operation of the room itself.

B. Provide aluminum channel supports and reinforcing for wall mounted shelving specified in Laboratory Casework Section, with approved anchorage to wall panels.

C. Provide refrigerant piping to and from condensing unit. Pipe condensate from evaporator to drain located on drawings. Install piping in accordance with manufacturer's instructions and in accordance with Division 22.

D. Mount condensing units to rack with easy access for service. Install rack and condensing unit with vibration eliminators.

E. Seal or otherwise insure that fastenings to rooms do not compromise vapor barriers or insulation. Seal between all piping and sleeves.

F. Provide all interconnecting power and control wiring from control panel to items in the room, such as receptacles and switches. Provide control wiring from remote condensing unit to control panel

G. Test and commission equipment after installation for compliance with performance requirements. Provide all required instrumentation. Instrumentation accuracy to exceed control tolerances indicated under the performance requirements in Part 1. Rooms shall operate a minimum of 2 weeks without a fault or alarm condition within performance tolerances, as a condition of Owner's acceptance.

H. Identification

1. Provide identification on electrical disconnects per section 16411 "Circuit Breakers, Disconnect Switches and Fuses" and section 16075 "Electrical Identification."

I. Environmental room manufacturer is responsible for final connection to building services. Building services will be provided in the vicinity.

3.4 CLEANING

A. Clean the Work upon completion in accordance with manufacturer's instructions.

3.5 DEMONSTRATION AND TRAINING

A. The manufacturer shall provide four copies of an operator's manual describing all operating and routine maintenance service procedures to be used with the equipment. Instruct the Owner's designated representatives in these procedures during the startup and test period.

B. Training shall be a 1-day, 6-hour session, conducted by a factory authorized service representative, on day agreeable to the Owner. Provide 14 days notice to the Owner.

END OF SECTION

SECTION 14 24 00

HYDRAULIC ELEVATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes hydraulic passenger elevators.

B. Related Requirements:
1. Division 03 "Cast-in-Place Concrete" for setting sleeves, inserts, and anchoring devices in concrete.
2. Division 05 "Metal Fabrications" for the following:
   a. Attachment plates and angle brackets for supporting guide-rail brackets.
   b. Divider beams.
   c. Hoist beams.
   d. Structural-steel shapes for subsills.
   e. Pit ladders.
   f. Cants in hoistways made from steel sheet.
   g. Stainless Steel wall base
3. Division 09”Resilient Tile Flooring” for finish flooring in elevator cars.
4. Division 22 "Sump Pumps" for sump pumps, sumps, and sump covers in elevator pits.
5. Division 27 "Communications Horizontal Cabling" for telephone service for elevators.
6. Division 28 "Digital, Addressable Fire-Alarm System" for smoke detectors in elevator lobbies to initiate emergency recall operation and for connection to elevator controllers.
7. Division 31 "Earth Moving" for excavating well hole to accommodate cylinder assembly.

1.3 DEFINITIONS

A. Definitions in ASME A17.1/CSA B44 apply to work of this Section.

1.4 ACTION SUBMITTALS

A. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information. Include product data for car enclosures, hoistway entrances, and operation, control, and signal systems.

B. Shop Drawings:
1. Include plans, elevations, sections, and large-scale details indicating service at each landing, machine room layout, coordination with building structure, relationships with other construction, and locations of equipment.
2. Include large-scale layout of car-control station and standby power operation control panel.
3. Indicate maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.

C. Samples for Initial Selection: For finishes involving color selection.

D. Samples for Verification: For exposed car, hoistway door and frame, and signal equipment finishes; 3-inch- square Samples of sheet materials; and 4-inch lengths of running trim members.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and electrical service including standby power generator, as shown and specified, are adequate for elevator system being provided.

C. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For elevators to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include diagnostic and repair information available to manufacturer's and Installer's maintenance personnel.

B. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.

C. Continuing Maintenance Proposal: Submit a continuing maintenance proposal from Installer to Owner, in the form of a standard one-year maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

D. Continuing Maintenance Proposal: Submit a continuing maintenance proposal from Installer to Owner with terms, conditions, and obligations as set forth in, and in same form as, "Draft of Elevator Maintenance Agreement" at end of this Section, starting on date initial maintenance service is concluded.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Elevator manufacturer or an authorized representative who is trained and approved by manufacturer.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials, components and equipment in manufacturer's protective packaging. Store materials, components, and equipment off of ground, under cover, and in a dry location.

1.9 COORDINATION

A. Coordinate installation of sleeves, block outs, elevator equipment with integral anchors, and other items that are embedded in concrete or masonry for elevator equipment. Furnish templates, sleeves, elevator equipment with integral anchors, and installation instructions and deliver to Project site in time for installation.

B. Furnish well casing and coordinate delivery with related excavation work.

C. Coordinate locations and dimensions of other work relating to hydraulic elevators including pit ladders; sumps and floor drains in pits; entrance subsills; electrical service; and electrical outlets, lights, and switches in hoistways, pits, and machine rooms.

1.10 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair, restore, or replace elevator work that fails in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.
   2. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Model LVM 3510T Passenger elevator by Otis Elevator Co. or comparable product by one of the following:
   1. Fujitec America, Inc.
   2. ThyssenKrupp Elevator.

B. Source Limitations: Obtain elevators from single manufacturer.
   1. Major elevator components, including pump-and-tank units, plunger-cylinder assemblies, controllers, signal fixtures, door operators, car frames, cars, and entrances, shall be manufactured by single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with ASME A17.1/CSA B44.

B. Accessibility Requirements: Comply with Section 407 in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and with ICC A117.1.

2.3 ELEVATORS

A. Elevator System, General: Manufacturer's standard elevator systems. Unless otherwise indicated, manufacturers' standard components shall be used, as included in standard elevator systems and as required for complete system.

B. Elevator Description:
   1. Type: Holeless, beside-the-car, telescoping, dual cylinder.
   2. Rated Load: 3500 lb.
   3. Rated Speed: 100 fpm.
   4. Operation System: Single automatic .
   5. Auxiliary Operations:
      a. Standby power operation.
      b. Standby-powered lowering.
      c. Battery-powered lowering.
      d. Automatic dispatching of loaded car.
      e. Nuisance call cancel.
      f. Priority service at all floors.
      g. Independent service for service elevator.
      h. Loaded-car bypass.

6. Security Features: Card-reader operation Keyswitch operation Keypad operation Car-to-lobby feature.
7. Car Enclosures:
   a. Inside Width: 80 inches from side wall to side wall.
   b. Inside Depth: 65 inches from back wall to front wall (return panels).
   c. Inside Height: 96 inches to underside of ceiling.
   d. Front Walls (Return Panels): Satin stainless steel, No. 4 finish with integral car door frames.
   e. Car Fixtures: Satin stainless steel, No. 4 finish.
   f. Side and Rear Wall Panels: Satin stainless steel, No. 4 finish .
   g. Reveals: Satin stainless steel, No. 4 finish .
   h. Door Faces (Interior): Polished stainless steel, No. 8 finish.
   i. Door Sills: Aluminum, mill finish.
   j. Ceiling: Luminous ceiling.
   k. Handrails: At sides and rear of car.
   l. Floor prepared to receive resilient flooring (specified in Division 09 "Resilient Flooring Tile").
   m. Floor Thickness, Including Setting Materials: Insert thickness above plywood subfloor.
8. Hoistway Entrances:
   a. Width: 42 inches.
   b. Height: 84 inches.
   c. Type: Single-speed side sliding.
   d. Frames : Satin stainless steel, No. 4 finish.
   e. Doors and Transoms: Satin stainless steel, No. 4 finish.
   f. Sills : Aluminum, mill finish.
9. Hall Fixtures : Satin stainless steel, No. 4 finish.
10. Additional Requirements:
   a. Provide inspection certificate in each car, mounted under acrylic cover with frame made from satin stainless steel, No. 4 finish.
   b. Provide hooks for protective pads in all cars and two complete set(s) of full-height protective pads.

2.4 SYSTEMS AND COMPONENTS

A. Pump Units: Positive-displacement type with a maximum of 10 percent variation between no load and full load and with minimum pulsations.
   1. Pump shall be submersible type with submersible squirrel-cage induction motor, and shall be suspended inside oil tank from vibration isolation mounts or shall be tank-top-mounted type with fan-cooled, squirrel-cage induction motor, and shall be mounted on oil tank with vibration isolation mounts and enclosed in prime-painted steel enclosure lined with 1-inch- thick, glass-fiber insulation board.
   2. Motor shall have wye-delta or solid-state starting.
   3. Motor shall have variable-voltage, variable-frequency control.

B. Hydraulic Silencers: System shall have hydraulic silencer containing pulsation-absorbing material in blowout-proof housing at pump unit.

C. Piping: Size, type, and weight of piping as recommended by elevator manufacturer, with flexible connectors to minimize sound and vibration transmissions from power unit.

D. Hydraulic Fluid: Nontoxic, biodegradable, fire-resistant fluid made from vegetable oil with antioxidant, anticorrosive, antifoaming, and metal-passivating additives and approved by elevator manufacturer for use with elevator equipment.
   1. Product: Subject to compliance with requirements, provide "Hydro Safe" by Hydro Safe Oil Division, Inc.

E. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work. Device installation is specified in another Section.

F. Corrosion-Protective Filler: A nontoxic, petroleum-based gel formulated for filling the space between hydraulic cylinder and protective casing. Filler shall be electrically nonconductive, displace or absorb water, and gel or solidify at temperatures below 60 deg F.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Hydro Safe Oil Division, Inc.; No-Ox-Id Liquid Elevator Casing Filler E-800.
      b. Union-Gard, a division of Dome Services L.L.C.; Union-Gard 160.

G. Car Frame and Platform: Welded or bolted steel units.

H. Guides: Roller guides; polymer-coated, nonlubricated sliding guides; or sliding guides with guide-rail lubricators. Provide guides at top and bottom of car and counterweight frames.

2.5 OPERATION SYSTEMS

A. General: Provide manufacturer's standard microprocessor operation system as required to provide type of operation indicated.

B. Auxiliary Operations: In addition to primary operation system features, provide the following operational features for elevators where indicated:
   1. Single-Car Standby Power Operation: On activation of standby power, car is returned to a designated floor and parked with doors open. Car can be manually put in service on standby power, either for return operation or for regular operation, by switches in control panel located at main lobby. Manual operation causes automatic operation to cease.
   2. Nuisance Call Cancel: When car calls exceed a preset number while car load is less than a predetermined weight, all car calls are canceled. Preset number of calls and predetermined weight can be adjusted.
   3. Loaded-Car Bypass: When car load exceeds 80 percent of rated capacity, car responds only to car calls, not to hall calls.
   4. Independent Service: Keyswitch in car-control station removes car from group operation and allows it to respond only to car calls. Key cannot be removed from keyswitch when car is in independent service. When in independent service, doors close only in response to door close button.
   5. Priority Service: Service is initiated by a keyswitch card readerremote switch at designated floors. One elevator is removed from group operation and directed to the floor where service was initiated. On arriving at the floor, elevator opens its doors and parks. Car is placed in operation by selecting a floor and pressing door close button or by operating keyswitch to put car in independent service. After responding to floor selected or being removed from independent service, car is returned to group operation. If car is not placed in operation within a preset time after being called, it is returned to group operation.

C. Security Features: Provide the following security features, where indicated. Security features shall not affect emergency firefighters' service.
   1. Card-Reader Operation: System uses card readers at car-control stations to authorize calls. Security system determines which landings and at what times calls require authorization by card reader. Provide required conductors in traveling cable and panel in machine room for interconnecting card readers, other security access system equipment, and elevator controllers. Allow space as indicated for card reader in car.
      a. Security access system equipment is specified in Division 28 "Access Control."
   2. Car-to-Lobby Feature: Feature, activated by keyswitch at main lobby, that causes car to return immediately to lobby and open doors for inspection. On deactivation by keyswitch, calls registered before keyswitch activation are completed and normal operation is resumed.

2.6 DOOR REOPENING DEVICES

A. Infrared Array: Provide door reopening device with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more light beams shall cause doors to stop and reopen.

B. Nudging Feature: After car doors are prevented from closing for predetermined adjustable time, through activating door reopening device, a loud buzzer shall sound and doors shall begin to close at reduced kinetic energy.

2.7 CAR ENCLOSURES

A. General: Provide steel-framed car enclosures with nonremovable wall panels, with removable car roof, access doors, power door operators, and ventilation.
   1. Provide standard railings complying with ASME A17.1/CSA B44 on car tops where required by ASME A17.1/CSA B44.

B. Materials and Finishes: Manufacturer's standards, but not less than the following:
   1. Subfloor: Exterior, C-C Plugged grade plywood, not less than 7/8-inch nominal thickness.
      a. Refer to Division 09 Resilient Tile Flooring section for floor finish requirements.
   2. Stainless-Steel Wall Panels: Flush, hollow-metal construction; fabricated from stainless-steel sheet.
      a. Wall base to be 4 inch stainless steel adhered to wall panel after installation of floor finish.
   3. Fabricate car with recesses and cutouts for signal equipment.
   4. Fabricate car door frame integrally with front wall of car.
   5. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet or by laminating stainless-steel sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
   6. Sight Guards: Provide sight guards on car doors.
   7. Sills: Extruded metal, with grooved surface, 1/4 inch thick.
   8. Luminous Ceiling: Fluorescent light fixtures and ceiling panels of translucent acrylic or other permanent rigid plastic.

2.8 HOISTWAY ENTRANCES

A. Hoistway Entrance Assemblies: Manufacturer's standard horizontal-sliding, door-and-frame hoistway entrances complete with track systems, hardware, sills, and accessories. Frame size and profile shall accommodate hoistway wall construction.
   1. Where gypsum board wall construction is indicated, frames shall be self-supporting with reinforced head sections.

B. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies shall comply with NFPA 80 and be listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction based on testing at as close-to-neutral pressure as possible according to NFPA 252 or UL 10B.
   1. Fire-Protection Rating: 1 hour with 30-minute temperature rise of 450 deg F.

C. Materials and Fabrication: Manufacturer's standards, but not less than the following:
   1. Steel Subframes: Formed from cold- or hot-rolled steel sheet, with factory-applied enamel finish or rust-resistant primer. Fabricate to receive applied finish as indicated.
   2. Stainless-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from stainless-steel sheet.
   3. Sight Guards: Provide sight guards on doors matching door edges.
   4. Sills: Extruded metal, with grooved surface, 1/4 inch thick.
   5. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M.

2.9 SIGNAL EQUIPMENT

A. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Fabricate lighted elements with long-life lamps and acrylic or other permanent, non-yellowing translucent plastic diffusers or LEDs.

B. Car Position Indicator: Provide illuminated, digital-type car position indicator, located above car door or above car-control station. Also, provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served. Include travel direction arrows if not provided in car-control station.

C. Hall Push-Button Stations: Provide one hall push-button station at each landing.
   1. Provide manufacturer's standard wall-mounted units.
   2. Equip units with buttons for calling elevator and for indicating applicable direction of travel.
   3. Provide telephone jack in each unit for firefighters' two-way telephone communication service specified in Section 283111 "Digital, Addressable Fire-Alarm System" Possibly insert a provision for either an "In Use" signal or a digital display of car position for single elevators.

D. Hall Annunciator: With each hall lantern, provide audible signals indicating car arrival and direction of travel. Signals sound once for up and twice for down.
   1. At manufacturer's option, audible signals may be placed on cars.

E. Hall Position Indicators: Provide illuminated, digital-display-type position indicators, located above each hoistway entrance at ground floor. Provide units with flat faceplate for mounting and with body of unit recessed in wall.
   1. Integrate ground-floor hall lanterns with hall position indicators.

F. Standby Power Elevator Selector Switches: Provide switches, as required by ASME A17.1/CSA B44, where indicated. Adjacent to switches, provide illuminated signal that indicates when normal power supply has failed. For each elevator, provide illuminated signals that indicate when they are operational and when they are at the designated emergency return level with doors open.

2.10 FINISH MATERIALS

A. General: Provide the following materials for exposed parts of elevator car enclosures, car doors, hoistway entrance doors and frames, and signal equipment as indicated.

B. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, commercial steel, Type B, exposed, matte finish.

C. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, commercial steel, Type B, pickled.

D. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304.

E. Stainless-Steel Bars: ASTM A 276, Type 304.

F. Stainless-Steel Tubing: ASTM A 554, Grade MT 304.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elevator areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work. Verify critical dimensions and examine supporting structure and other conditions under which elevator work is to be installed.

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

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

3.2 INSTALLATION

A. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor and braced at intervals as needed to maintain alignment. Anchor cylinder guides at spacing needed to maintain alignment and avoid overstressing guides.

B. Welded Construction: Provide welded connections for installing elevator work where bolted connections are not required for subsequent removal or for normal operation, adjustment, inspection, maintenance, and replacement of worn parts. Comply with AWS workmanship and welding operator qualification standards.

C. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts to minimize vibration transmission to structure and structure-borne noise due to elevator system.

D. Install piping above the floor, where possible. Install underground piping in casing.

E. Lubricate operating parts of systems as recommended by manufacturers.

F. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with car. Where possible, delay installation of sills and frames until car is operable in shaft. Reduce clearances to minimum, safe, workable dimension at each landing.

G. Leveling Tolerance: 1/4 inch, up or down, regardless of load and travel direction.

H. Set sills flush with finished floor surface at landing. Fill space under sill solidly with nonshrink, nonmetallic grout.

I. Locate hall signal equipment for elevators as follows, unless otherwise indicated:
   1. For groups of elevators, locate hall push-button stations between two elevators at center of group or at location most convenient for approaching passengers.
   2. Place hall lanterns either above or beside each hoistway entrance.
   3. Mount hall lanterns at a minimum of 72 inches above finished floor.

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of elevator installation and before permitting elevator use (either temporary or permanent), perform acceptance tests as required and recommended by ASME A17.1/CSA B44 and by governing regulations and agencies.

B. Advise Owner, Architect, and authorities having jurisdiction in advance of dates and times that tests are to be performed on elevators.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate, adjust, and maintain elevator(s).

B. Check operation of each elevator with Owner's personnel present before date of Substantial Completion and again not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.

3.5 MAINTENANCE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include twelve months' full maintenance by skilled employees of elevator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
   1. Perform maintenance during normal working hours.
   2. Perform emergency callback service during normal working hours with response time of two hours or less.
   3. Include 24-hour-per-day, 7-day-per-week emergency callback service with response time of two hours or less.

END OF SECTION

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SECTION 20 00 00

GENERAL MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.2 DESCRIPTION

A. Intent of drawings and Specifications is to obtain complete systems, tested, adjusted, and ready for operation.

B. Except as otherwise defined in greater detail, the terms "provide", "furnish" and "install" as used in Division 20, 21, 22 and 23 Contract Documents shall have the following meanings:
   1. "Provide" or "provided" shall mean "furnish and install".
   2. "Furnish" or "furnished" does not include installation.
   3. "Install" or "installed" does not include furnishing.

C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.

D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.

E. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for exact dimensions.

F. Where Architectural features govern location of work, refer to architectural drawings.

G. Contractor may install additional piping, fittings and valves, not shown on drawings, for testing purposes or for convenience of installation. Where such materials are installed, they shall comply with specifications and shall be sized to be compatible with system design. Remove such installed materials when they interfere with design conditions or as directed by Architect.

1.3 RELATED WORK

A. Utility Services:
   1. Determine utility connection requirements and include in Base Bid all costs to Laboratory for utility service.
   2. Include costs for temporary service, temporary routing of piping or any other requirements of a temporary nature associated with utility service.

B. Temporary Services:
   1. Division 01 - Temporary Facilities and Controls.

C. Continuity of Service:
   1. No service shall be interrupted or changed without permission from Architect and Laboratory. Obtain written permission before any work is started.
   2. When interruption of services is required, Architect, Laboratory, and other concerned parties shall be notified and shall determine a time.

D. Demolition:
   1. Division 02 - Selective Demolition.
   2. Perform demolition as required to accomplish new work.
   3. Accomplish work in neat workmanlike manner to minimize interference, annoyance or inconvenience such work might impose on Laboratory or other Contractors.
   4. Unless otherwise noted, remove from premises materials and equipment removed in demolition work.
   5. Equipment noted to be removed and turned over to Laboratory, shall be delivered to Laboratory at place and time Laboratory designates.
   6. Where materials are to be turned over to Laboratory or reused and installed by Contractor, it shall be Contractor's responsibility to maintain condition of materials and equipment equal to that existing before work began. Repair or replace damaged materials or equipment at no additional cost to Laboratory.
   7. Where demolition work interferes with Laboratory's use of premises, schedule work through Architect, Laboratory and with other Contractors to minimize inconvenience to Laboratory. Architect must approve schedule before Contractor begins such Work.

E. Concrete Work:
   1. Provide cast-in-place concrete as required by Contract Documents unless otherwise noted.
   2. Concrete shall comply with Division 03 - Concrete.
   3. Provide anchor bolts, metal shapes and templates required to be cast in concrete or used to form concrete for support of mechanical equipment.

F. Painting:
   1. Painting of mechanical equipment will be done under Division 09 unless specified otherwise or unless equipment is to be furnished with factory applied finish coats.
   2. Furnish equipment with factory applied prime finish unless otherwise specified.
   3. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Architect.
   4. Furnish one can of touch up paint for each factory-applied coat of product.

1.4 REQUIREMENTS OF REGULATORY AGENCIES

A. Rules and regulations of Federal, State and Local Authorities and utility companies, in force at time of execution of Contract shall become part of this specification.

1.5 REFERENCE STANDARDS

A. Agencies or publications referenced herein refer to the following:
   1. AGA American Gas Association
   2. AMCA Air Movement and Control Association
   3. ANSI American National Standards Institute
   4. ARI Air-Conditioning and Refrigeration Institute
   5. ASHRAE American Society of Heating Refrigerating and Air Conditioning Engineers
   6. ASPE American Society of Plumbing Engineers
   7. ASSE American Society of Sanitary Engineering
   8. AWS American Welding Society
   9. AWWA American Water Works Association
   10. ASME American Society of Mechanical Engineers
   11. ASTM American Society for Testing and Materials

12. CISPI Cast Iron Soil Pipe Institute
13. FMG FM Global
14. FS Federal Specifications
15. IEEE Institute of Electrical and Electronics Engineers
16. MCA Mechanical Contractors Association
17. MSS Manufacturers Standardization Society
18. NEC National Electrical Code
19. NEMA National Electrical Manufacturers Association
20. NFPA National Fire Protection Association
21. NIST National Institute of Standards & Technology
22. NSF National Sanitation Foundation
23. NSPI National Spa and Pool Institute
24. OSHA Occupational Safety and Health Administration
25. PDI Plumbing and Drainage Institute
26. SMACNA Sheet Metal and Air Conditioning Contractors National Association
27. UL Underwriters Laboratories, Inc.
28. WCF Water Conditioning Foundation

B. Work shall be in accordance with latest edition of codes, standards or specifications unless noted otherwise.

1.6 SUBMITTALS

A. Shop Drawings (Product Data):
1. Refer to Division 01 - Submittal Procedures.
2. Note that for satisfying submittal requirements for Divisions 20, 21, 22 or 23, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 01. However, the expression "Shop Drawings" is generally used throughout Specification.
3. Submit shop drawings for equipment and systems as requested in the respective specification sections. Submittals that are not requested may not be reviewed.
4. Specifically mark general catalog sheets and drawings to indicate specific items submitted and its correlation to specific designation for product in drawings.
5. Specifically indicate proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
6. When manufacturer's reference numbers are different from those specified, provide correct cross-reference numbers for each item. Clearly mark and note submittals accordingly.
7. Submit complete record of required components when fixtures, equipment and items specified include accessories, parts and additional items under one designation.
8. Include composite wiring diagrams for electrically powered equipment and devices.
9. Submit equipment room layouts drawn to scale, including equipment, piping, accessories and clearance for maintenance.
10. Where submittals cover products containing non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
11. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
12. Submittals that are not complete, not permanent or not properly checked by Contractor will be returned without review.

13. "Coordination Drawings", which are normally prepared by Contractor to coordinate work among various trades and to facilitate installation, shall not be submitted for Division 20, 21, 22 or 23 work unless specifically requested in technical sections. These types of drawings typically include dimensioned piping, ductwork or electrical raceway layouts.
14. Unless specifically requested in Division 20, 21, 22 or 23 technical sections, submittals of coordination drawings will be returned without review.

B. Certificates and Inspections:
1. Obtain and pay for inspections required by authorities having jurisdiction and deliver certificates approving installations to Laboratory unless otherwise directed.

C. Operation and Maintenance Manuals:
1. Refer to Division 01 - Operation and Maintenance Data.
2. Upon completion of Work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2” thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to Laboratory.
3. Organize manuals by specification section number and furnish table of contents and tabs for each piece of equipment or system.
4. Fire protection system shall be separately bound.
5. Manuals shall include the following:
   a. Copies of Shop Drawings
   b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment, with component exploded views and part numbers. Where manufacturer's data includes several types or models, designate applicable type or model.
   c. CD ROM's of O&M data with exploded parts lists where available
   d. Phone numbers and addresses of local parts suppliers and service companies
   e. Internet/WEB page addresses where applicable
   f. Wiring diagrams
   g. Startup and shutdown procedures
   h. Composite electrical diagrams
   i. Flow diagrams
   j. Lubrication instructions
   k. Factory and field test records (Refer to Test and Balancing in Part 3 of this section.)
   l. Air and water balance reports
   m. Valve identification charts as specified in Section 20 0553 - Mechanical System Identification
   n. Access panel identification charts as specified in Section 20 0553 - Mechanical System Identification
   o. Additional information, diagrams or explanations as designated under respective equipment or systems specification sections.
6. Instruct Laboratory's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
7. Furnish O&M Manuals and instructions to Laboratory prior to request for final payment.

D. Record Documents:
1. Refer to General Conditions of Contract, and Division 01 - Project Record Documents. Prepare complete set of record drawings in accordance with Division 01.

2. Use designated set of prints of Contract Documents as prepared by Architect to mark-up for record drawing purposes.

1.7 JOB CONDITIONS

A. Building Access:
   1. Arrange for necessary openings in building to allow for admittance of all apparatus.

B. Electrical Coordination:
   1. Refer to Section 20 0513 - Motors
   2. Contractors for Divisions 20, 21, 22 and 23 shall provide the following items as specified under their respective Division(s) (Division 20, 21, 22 and 23):
      a. Motors
      b. Electrically powered equipment
      c. Electrically controlled equipment
      d. Starters, where specified
      e. Variable frequency drives, where specified
      f. Control devices, where specified
      g. Temperature Control wiring
      h. Wiring diagrams to Electrical Contractor for apparatus indicating external connection and internal controls.
      i. Disconnect devices furnished with units (VFDs, chillers, prepackaged control devices, etc.)
         1). Devices shall have an interrupting rating not less than that of the upstream overcurrent device as shown on electrical drawings.
   3. Electrical Contractor will provide the following devices required for control of motors or electrical equipment, unless noted otherwise.
      a. Starters
      b. Disconnect devices
      c. Control devices:
         1). Pushbuttons
         2). Pilot lights
         3). Contacts
      d. Conduit, boxes and wiring for power wiring.
      e. Conduit, boxes and wiring for control wiring, except temperature control wiring.
   4. Electrical Contractor will make connections, from power source to starter or variable frequency drive and from starter or variable frequency drive, where specified, to motor for ready to operate.
   5. Where starters or other similar control devices are furnished by this contractor, they shall be installed by this contractor and wired by Electrical Contractor.
   6. Should any change in size, hp rating, voltage, or means of control be made to any motor or other electrical equipment after Contracts are awarded, this contractor shall immediately notify Electrical Contractor of change. Additional costs due to these changes shall be responsibility of this contractor.

C. Cutting and Patching:
   1. Refer to General Conditions of the Contract, and Division 01 - Cutting and Patching.
   2. Perform cutting and patching required for complete installation of systems, unless otherwise noted. Patch and restore work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
   3. Provide materials required for patching unless otherwise noted.

4. Do not pierce beams or columns without written permission of Architect/Structural Engineer of Record and then only as directed. If openings are required through walls or floors where no sleeve has been provided:
   a. Architect/Structural Engineer of Record written approval is required
   b. Floor or wall shall be Xrayed to locate reinforcement. Core shall be placed in location where reinforcement will not be cut or damaged.
5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

D. Housekeeping and Cleanup:
1. Refer to Division 01 - Closeout Procedures.
2. As work progresses and/or as directed by Architect, periodically remove waste materials from building and leave area of work broom clean. Upon completion of Work, remove tools, scaffolding, broken and waste materials, etc., from site.

1.8 WARRANTY

A. Refer to Division 01 for general warranty requirements.

B. Refer to technical sections for warranty requirement for each system.
1. Where no warranty requirements are called out, warrant [as called out in Division 01] [for 1 year after acceptance by Laboratory] equipment, materials, and workmanship to be free from defect.

C. Warrant that systems will operate without objectionable noise, vibration and uncontrolled expansion.

D. Repair, replace or alter systems or parts of systems found defective at no extra cost to Laboratory.

E. In any case, wherein fulfilling requirements of any guarantee, if this contractor disturbs any work guaranteed under another contract, this contractor shall restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such other contract.

F. Warranty shall include labor, materials, and travel time.

PART 2 - PRODUCTS

2.1 PRODUCT SUBSTITUTIONS

A. Refer to Division 01 - Product Requirements.

PART 3 - EXECUTION

3.1 GENERAL

A. Verify elevations and dimensions prior to installation of materials.

3.2 EXCAVATION AND BACKFILL

A. Refer to Division 31 - Earthwork.

B. Provide excavation and backfill for underground work unless otherwise indicated. Blasting is not allowed on this project without written permission of Architect and Laboratory.

C. Backfill trenches beneath concrete floor and stair slabs within building and beneath concrete slabs, walks, stairs and drives at exterior of building with gravel fill and compact to same density as surrounding area.

3.3 FLOOR, WALL, ROOF AND CEILING OPENINGS

A. Coordinate location of openings, chases, furred spaces, etc., with appropriate Contractors. Provide sleeves and inserts that are to be built into structure during progress of construction.

B. Remove temporary sleeves, if used to form openings, prior to installation of permanent materials. Utilize minimum 24 ga galvanized sheet metal for permanent sleeves unless otherwise noted.

C. Provide Schedule 40 carbon steel pipe with integral water stop for steel sleeves required in interior floor slabs.

D. Submit to Structural Engineer for review and approval size and location of core-drilled holes prior to execution.

E. Submit product data and installation details for penetrations of building structure. Include schedule indicating penetrating materials (metal pipe, plastic pipe, conduit, etc.), sizes of each, opening sizes and sealant products intended for use.

F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Section 20 0573 - Mechanical Systems Firestopping.

G. Submit complete penetration layout drawings showing openings in building structural members including floor slabs, bearing walls, shear walls, etc. Indicate and locate, by dimension, all required openings, including those sleeved, formed or core drilled. Drawings shall be approved prior to preparing openings in structural member.

H. Provide minimum 1” clearance around penetration openings intended for pipe. Where fire resistant penetrations are required, size openings in accordance with written recommendations of firestopping systems manufacturer.

I. Openings for underground pipes passing through foundations shall have minimum clearance of 1/4” to concrete. Do not disturb footing bearing soil. Underground pipes shall not pass under footings.

J. Openings for underground pipe passing through on grade concrete slabs shall have minimum 1/4” clearance to concrete. Seal openings with urethane caulk.

K. Openings for insulated piping shall be sized based on outside diameter of insulation when it is specified or detailed to be continuous through opening.

L. Openings for duct penetrations shall be no more than 1/2” larger on all sides than size of duct or duct including duct insulation, if applicable. Where firestopping systems are required at penetrations, size in accordance with recommendations of firestopping systems manufacturer, but opening shall not exceed 1” average clearance on all sides. Openings for ducts with fire dampers shall be in accordance with fire damper installation requirements.

M. Duct penetrations through concrete floors in mechanical rooms containing liquid heat exchangers and/or pumps shall have 2” high water stopped curbs surrounding openings. This applies to mechanical rooms above the lowest floor level.

N. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.

O. Seal non fire-rated wall openings with urethane caulk.

P. Where penetrations occur through exterior walls into building spaces, use sleeves with integral water stop. For piping having outer surface temperature less than 150°F, use plastic (HDPE) sleeves, similar to PSI Link-Seal Model CS, rated to 150°F. For piping having outer surface temperature 150°F or higher, or where steel sleeves are shown or walls are fire rated, use steel sleeves with hot dip galvanizing, similar to PSI Link-Seal Model WS. Seal annular space between sleeves and pipe with Thunderline "Link-Seal" modular wall and casing seals, or sealing system by another manufacturer approved as equal by Engineer. Where "Link-Seals" are used with insulated pipe, insulation shall be butted against seals on both sides. Sealing system shall utilize Type 316 stainless steel bolts, washers and nuts.

Q. In lieu of openings as specified herein penetration systems as manufactured by Pro Set may be used, including sleeve couplings and plug.

R. If total Pro Set system with Water Guard “CR” is used, opening shall not need additional water proofing or riser clamps.

S. Finish and trim penetrations as shown on details and as specified.

T. Provide chrome or nickel plated escutcheons where piping passes through walls, floors or ceilings and is exposed in finished areas. Size escutcheons to fit pipe and pipe covering for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitors' closets, storage rooms, etc., unless suspended ceilings are specified.

U. Trim duct penetrations exposed in finished areas with 2” wide galvanized or aluminum trim collars properly sized to fit duct. Collars shall be same gauge as duct, prime finish unless noted otherwise. Finished areas shall not include mechanical rooms, janitors' closets, storage rooms, etc., unless suspended ceilings are specified.

V. In [GMP clean room] [Bio-safety] [Animal holding] [Wash down] areas,
   1. Exposed conduit penetrations shall be sealed as follows:
      a. Escutcheons shall not be used when conduits are exposed in finished areas and penetrate finished surfaces.
      b. Cut and patch penetration to within 1/4” of conduit.
      c. Seal openings around conduit and patch work with [sealants specified in Division 07 – Joint Sealants.] [sprayable, flexible, liquid polyvinyl chloride coating equal to ANDEK "COCOON® 72634-USDA"]. Sealant shall be installed per manufacturer's application requirements.
      d. [ANDEK Corp., 850 Glen Avenue, P.O. Box 392, Moorestown, New Jersey 05857-0392.]
   2. Penetrations other than conduits (junction boxes, light fixtures, etc.) including wiring devices shall be sealed as follows:
      a. Seal non-rated opening with silicone sealant.
      b. See drawings for details.
      c. Confirm selected sealant is compatible with paint provided by others prior to application.
      d. Product: One-Part Mildew-Resistant Silicone Sealant: Type S; Grade NS; Class 25; Uses NT, G, A, and as applicable to nonporous joint substances indicated, O; formulated with fungicide; intended for sealing interior joints with nonporous substrates and subject to in-service exposure to conditions of high humidity and temperature extremes; subject to compliance with requirements. Provide one of the following:
         1). 786 Mildew Resistant Silicone Sealant; Dow Corning Corp.
         2). Sanitary 1700 Silicone Sealant; General Electric Co.
         3). 898 Silicone Sanitary Sealant; Pecora Corp.
         4). Tremsil 600; Tremco Corp.
         5). OmniPlus; Sonneborn Building Products Div., Rexnord Chemical Products, Inc.

3.4 EQUIPMENT SHUTOFF VALVES

A. Provide shutoff valves at equipment connected to piping system. Refer to valve section or system section for requirements of valve type.

3.5 EQUIPMENT ACCESS

A. Install piping, conduit and accessories to permit access to equipment for maintenance. Relocate piping, equipment or accessories to provide access at no additional cost to Laboratory.

B. Install equipment with sufficient maintenance space for removal, repair or changes to equipment. Provide ready accessibility to equipment without moving other future or installed equipment or system components.

C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 08 - Access Doors and Frames, unless otherwise indicated. Access doors for valves, shock stops or other equipment shall provide access for servicing, repairs, and/or maintenance.

D. Provide necessary coordination and information to the Trade Contractor under Division 08 - Access Doors and Frames. This information shall include required locations, sizes, and rough-in dimensions.

E. Provide access doors in walls, chases or above inaccessible ceilings for valves, shock stops, unions or equipment/devices requiring access for servicing, repairs or maintenance , unless otherwise noted. Access frames and doors shall be as manufactured by Milcor, Incorporated, or similar, of style applicable to surface. Provide access doors used in fire rated construction with UL Label. Provide steel, prime coated access doors unless otherwise specified. Provide stainless steel doors in ceramic tile walls, toilet rooms, locker rooms and in areas subject to excessive moisture. Provide access doors of sufficient size to allow complete maintenance. Coordinate location of access doors with General Contractor and rough-in equipment accordingly.

3.6 EQUIPMENT SUPPORTS

A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers, etc.

3.7 EQUIPMENT GUARDS

A. Provide equipment guards over belt driven assemblies, pump shafts, exposed fans, and elsewhere as indicated in this Specification or required by Code.

B. Paint equipment guards bright yellow.

C. Equipment guards shall comply with OSHA requirements.

3.8 SUPPORT PROTECTION

A. In occupied areas, mechanical rooms and areas requiring normal maintenance access, guard certain equipment to protect personnel from injury.

B. Provide minimum 1/2”thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment and mechanical supporting devices suspended less than 7 ft. above floors, platforms or catwalks in these areas.

C. Protect threaded rod or bolts at supporting elements as described above. Trim threaded rod or bolts such that they do not extend beyond supporting element.

3.9 MECHANICAL SYSTEMS IDENTIFICATION

A. Refer to Section 20 0553 - Mechanical Systems Identification

3.10 TEST AND BALANCING

A. Tests for equipment, ductwork and piping systems shall be performed as specified in their respective specification sections in accordance with technical requirements noted.

B. Provide equipment required for testing, including fittings for additional openings required for test apparatus.

C. All ductwork and piping inspections and testing shall be successfully completed and approved before application of covering materials.

D. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or material as necessary and repeat inspection and test until equipment or systems meet test requirements. Make repairs with new materials. Caulking of holes or threaded joints is not allowed.

E. Contractor is responsible for certifying in writing equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria, test medium and pressure used, duration of test and name and title of person signing test certification document.

F. Maintain copies of certified test results, including those for any failed tests, at project site. At completion of project, include copies of test records and certifications in O&M Manuals.

G. Balancing of various systems shall be in accordance with associated specification sections in addition to requirements noted herein.

H. If exterior domestic water supply also serves as source for fire protection systems, either exterior or interior or both, it shall be tested according to fire protection system requirements as specified in applicable Specification Section.

3.11 START-UP

A. Systems and equipment shall be started, tested, adjusted and turned over to Laboratory ready for operation. This includes "Laboratory-Furnished, Contractor-Installed" (OFCI) and "Contractor-Furnished, Contractor-Installed" (CFCI) systems and equipment.

B. Follow manufacturer's pre-start-up check-out, start-up, trouble shooting and adjustment procedures.

C. Contractor shall provide services of technician/mechanic knowledgeable in start-up and check-out of types of systems and equipment on project.

D. Provide start-up services by manufacturer's representative where specified or where Contractor does not have qualified personnel.

E. Coordinate start-up with all trades.

3.12 COMMISSIONING

A. Perform Commissioning in accordance with the requirements of Sections 22 90 00 and 23 90 00.

3.13 LUBRICATION

A. Upon completion of work and before turning over to Laboratory, clean and lubricate bearings except sealed and permanently lubricated bearings. Use only lubricant recommended by manufacturer.

B. Contractor is responsible for maintaining lubrication of mechanical equipment under this Contract until Work is accepted by Laboratory.

3.14 CLEANING

A. Clean systems after installation is complete.

B. Clean piping and ductwork both internally and externally to remove dirt, plaster dust or other foreign materials. When external surfaces of piping are rusted, clean and restore surface to original condition.

C. Clean pipeline strainers to restore them to original condition or replace with new strainer elements.

D. Clean equipment and plumbing fixtures as recommended by manufacturers.

E. Replace throwaway or replaceable media air filters used during construction period with new filters or new filter media after construction has been completed and before building is turned over to Laboratory. Filter replacement shall be as hereinafter specified.

F. Blow and clean dirt, plaster dust and other foreign matter from coils, terminal devices, diffusers, registers and grilles.

G. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.

H. Provide additional cleaning of individual piping systems and apparatus as hereinafter specified.

End of Section

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SECTION 20 05 13

MOTORS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 05 14 - Variable Frequency Drive (VFD) System

B. Section 26 29 13 - Enclosed Controllers

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer
   2. hp, voltage, phase, hertz, rpm
   3. Motor type
   4. Enclosure type
   5. Frame type
   6. Insulation class
   7. NEMA design designation
   8. Service factor
   9. Nominal efficiency at full load
   10. Power factor at full load
   11. Full load amperes
   12. Bearings
   13. Mountings
   14. Dimensions
   15. Weight
   16. Shaft grounding brush for motors driven by Variable Frequency Drives (VFD)

1.4 PRODUCT CRITERIA

A. Motors covered by this Specification shall conform to applicable requirements of NEMA, IEEE, ANSI, and NEC Standards and shall be UL Listed where applicable for service specified.

B. Motors shall be designed for conditions in which they will be required to perform; i.e., general purpose, splash proof, explosion proof, standard duty, high torque or other special type as required by equipment manufacturers.

C. Select motors so they do not exceed nameplate rating nor operate into service factor to meet specified duty.

D. Motors located inside AHU’s and exposed motors (motors not protected by factory installed weather proof housings) located in outdoor or wash down environments shall have totally enclosed fan cooled (TEFC) enclosures.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials shall be new and guaranteed for service intended.

2.2 MOTORS

A. Voltage Ratings
   1. Refer to equipment schedules and specification sections for voltages required.
   2. Unless otherwise indicated, motors 1/3 hp and smaller shall be rated 115 V for operation on 120 V, 1 Ph, 60 Hz service.
   3. Unless otherwise indicated, motors 1/2 hp and larger shall be rated:
      a. 460 V for operation on 480 V, 3 Ph, 60 Hz service.

B. Motors shall be 4 pole (approximately 1750 rpm) unless otherwise noted.

C. Single-phase motors shall be furnished with built-in thermal overload protection.

D. Use NEMA Design B motors, normal starting torque with regreasable ball bearings rated for minimum of 26280 hours L-10 life at full-load, and Class B insulation unless specified otherwise or unless manufacturer of equipment on which motor is being used has more stringent requirements.

E. Motors shall be rated continuous duty and have 1.15 service factor unless otherwise noted.

F. Motors Driven by Variable Frequency Drives (VFD)
   1. Motors shall comply with the latest NEMA MG-1, Section IV, Part 31.
   2. Motors shall have service factor not less than 1.0 at rated load.
   3. Furnish each motor with shaft grounding brush similar to AEGIS SGR to prevent bearing from shaft current.

G. Vibration shall not exceed .015” per second, unfiltered peak unless otherwise noted.

H. Motors (180 frames and larger) shall have provisions for lifting eyes or lugs capable of safety factor of 5.

I. Full load nominal efficiency of motors 1 hp and larger, except special-purpose motors including 2-speed or multi-speed motors, and rewound motors, shall meet or exceed listed values when tested in accordance with IEEE Standard 112 Method B as defined by NEMA Standard MG 1-12.6C. Efficiency values listed are based on NEMA Premium Efficiency Motors of NEMA MG 1-2006, Table 12-12.

	Open Drip-Proof Motors			Totally Enclosed Fan-Cooled Motors		
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
hp	(6 pole)	(4 pole)	(2 pole)	(6 pole)	(4 pole)	(2 pole)
	82.5	85.5	77.0	82.5	85.5	77.0
1 hp	86.5	86.5	84.0	87.5	86.5	84.0
1.5 hp	87.5	86.5	85.5	88.5	86.5	85.5
2 hp	88.5	89.5	85.5	89.5	89.5	86.5
	89.5	89.5	86.5	89.5	89.5	88.5
3 hp	90.2	91.0	88.5	91.0	91.7	89.5
5 hp	91.7	91.7	89.5	91.0	91.7	90.2
7.5 hp	91.7	93.0	90.2	91.7	92.4	91.0
	92.4	93.0	91.0	91.7	93.0	91.0
10 hp	93.0	93.6	91.7	93.0	93.6	91.7
15 hp	93.6	94.1	91.7	93.0	93.6	91.7
20 hp	94.1	94.1	92.4	94.1	94.1	92.4
25 hp	94.1	94.5	93.0	94.1	94.5	93.0
30 hp	94.5	95.0	93.6	94.5	95.0	93.6
40 hp	94.5	95.0	93.6	94.5	95.4	93.6
	95.0	95.4	94.1	95.0	95.4	95.0

J. Single-phase motors for hard starting applications including outdoor applications shall be capacitor start type. Motors for fans and pumps located indoors may be split phase or permanent split-capacitor. Motors shall be equipped with permanently lubricated and sealed ball bearings and shall be selected for quiet operation. Motors 1/8 hp and below may be shaded pole type.

1. Refer to individual equipment section for additional requirements or specific type of motors.

K. 3 Ph, 2-speed motors shall be one winding, consequent pole, variable torque type and 1 Ph, 2-speed motors shall be capacitor start capacitor run type.

L. When submersible pumps are specified, each pump shall include in addition to controls specified, all necessary controls, relays, wiring, etc. that may be required for safety features incorporated in motor design. No submersible motor shall be run or activated until all requirements of motor manufacturer's recommendations have been complied with.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install materials in accordance with drawings, approved Shop Drawings and manufacturer's recommendations.

End of Section

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SECTION 20 05 14

VARIABLE FREQUENCY DRIVE (VFD) SYSTEM

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 05 13 - Motors

B. Section 23 09 01 - Control Systems Integration

C. Section 23 09 93 - Control Sequences

D. Section 23 21 23 - Pumps

E. Section 23 34 00 - Fans

F. Section 23 73 23 - Factory Fabricated Custom Air Handling Units

G. Section 26 28 16 - Enclosed Switches and Circuit Breakers

H. Section 26 29 13 - Enclosed Controllers

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 SYSTEM DESCRIPTION

A. Provide Variable Frequency Drives (VFD) for each pump, fan or other driven equipment sized to accommodate motors shown on drawings or schedules. All VFD's shall be from same manufacturer.

B. VFD manufacturer shall review driven equipment and motors for VFD compatibility. Submit written statement from manufacturer of driven equipment along with VFD shop drawing submittals, indicating verification of compatibility.

C. Contractor shall verify distance from motors to VFD's. VFD manufacturer shall provide sufficient equipment to assure proper operation and to avoid premature motor failure.

D. VFD manufacturer shall provide filter equipment as necessary to limit voltage transient ring wave stress placed on stator windings to withstand rating value of motors supplied per Section 20 0513 - Motors.

E. VFD shall vary speed of its respective fan, pump or other driven equipment motor in response to either 4-20 mA or 0-10 VDC control signal provided by Control Contractor.

F. VFD system shall consist of the following:
   1. Variable frequency drive
   2. UL Listed disconnect device
   3. Electrical noise attenuation device as required to meet electrical noise criteria
   4. Motor starter for bypass mode operation with VFD/OFF/BYPASS selector and drive input and output isolation contactors where VFD bypass starters are specified.
   5. Line reactor

6. Step-up or step-down isolation transformer as required

1.4 QUALIFICATIONS

A. VFD system shall be furnished by a manufacturer with at least 5 yrs experience in design, construction and application of VFD.

1.5 SUBMITTALS

A. Shop Drawings for each VFD system including, but not limited to, the following:
   1. Manufacturer's name
   2. Identification of system components
   3. Type of enclosure, front elevation and plan view, equipment weight, conduit access locations
   4. Capacities/ratings
   5. Warranty
   6. System wiring and block diagram showing system components
   7. Performance, control and protection data with specified features clearly shown
   8. Operating and monitoring devices with specified features clearly indicated
   9. Start-up operation, maintenance, spare parts, and field tests
   10. Manufacturer's installation instructions
   11. Other appropriate data
   12. Variations from this Specification

B. After quality assurance tests are complete, submit written certification that drive and components have passed factory quality assurance tests.

C. Submit calculations indicating conformance with electrical noise criteria specified. Refer to Electrical Documents for information regarding electrical building distribution system.

D. Submit product and performance data on electrical noise attenuation device if required to meet electrical noise criteria specified. Isolation transformer is not electrical noise attenuation device.

1.6 ELECTRICAL NOISE CRITERIA

A. Voltage and current distortion generated by VFD and attenuation devices measured at input and output of VFD assembly and as installed in place, shall not exceed the following criteria as referenced by IEEE Standard 519.
   1. Total harmonic distortion (THD) shall not exceed 5% RMS of fundamental input voltage at full load with maximum RMS value on any signal harmonic based on IEEE 519-1992 Table 10.3.
   2. Area of commutation notch (A_n) shall not exceed 16,400 voltmicroseconds measured at point of coupling to distribution system. Point of common coupling shall secondary side of upstream outdoor transformer.

B. VFD manufacturer shall perform harmonic analysis at input of distribution transformer to define submittals that compliance to IEEE-519-1992, General Category, is attained. Analysis shall include electrical one line drawing defining resistance and impedance of each wire run and transformer leading to each VFD. Analysis shall be computer generated and perform Fourier analysis of the system. Results shall list current and voltage amplitudes of all harmonics up to 50th level at input of distribution transformer. A summary shall detail percent total harmonic distortion for voltage and total demand distortion for current. Study shall assume maximum transformer loading of 75% of nameplate value.

C. Drive type shall be based on findings of the IEEE 519 study with minimum configurations based on motor horsepower as indicated by the following:

1. Less than 50 hp – 6 pulse

D. Electrical one line diagrams shown on Electrical Drawings include transformer kVA and impedance, and typical configuration of electrical system. Use this information for evaluation of harmonics for bidding purposes.

E. Successful contractor must provide required data for VFD manufacturer to complete harmonic analysis. Information shall include utility short circuit amperes capability; distribution transformer kVA and impedance; length, size and number of wires per phase to motor control center feeding VFD's; wire data to VFD's from motor control center; wire data to motor from VFD; and motor nameplate data.

F. VFD manufacturer is responsible for cost of all equipment required to meet IEEE-519. Equipment, which can be provided, includes input line reactors, DC bus reactors and harmonic filters.

1.7 START-UP OPERATION AND MAINTENANCE DATA

A. Manufacturer shall provide services of factory trained engineer or technician to approve installation; start-up test and adjust for proper operation; and instruct and train Laboratory's representative in operation and maintenance of VFD systems. Provide minimum of 4 h of Laboratory training for VFD system.

B. Coordinate with the BAS Contractor and the Balancing Contractor.

C. Should drive be deficient, drive manufacturer shall be required to make changes necessary to bring units into compliance with specified performance requirements. Cost of changes and retest shall be borne by drive manufacturer.

D. Upon completion of this service, submit a report signed by manufacturer's service representative, including start-up and test log.

E. Manufacturer shall include additional 2 yr (total 3 yrs) warranty for VFD system, covering parts, labor and travel expenses.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Manufacturers: ABB, Allen Bradley/Rockwell Automation, AC Tech, Emerson, Cutler-Hammer, Danfoss Graham, GE, Yaskawa (MagneTek), Reliance/Rockwell Automation, or Toshiba

2.2 FABRICATION

A. VFD shall be variable torque, solid state, microprocessor based control, modular design for standard induction AC motor.

B. VFD components shall be factory mounted and wired in NEMA 1 enclosure with lock.

C. VFD components shall be factory mounted and wired in Motor Control Center enclosure.

D. Circuitry shall be plug-in, plug-out modular. Printed circuit boards shall have protective coating to reduce corrosion.

E. Unit shall conform to NEMA and NEC standards and be CSA, UL or ETL Listed. Control circuitry shall be electrically isolated from power circuitry. Entire assembly panel shall have UL or equivalent panel sticker.

F. Invertor section shall be pulse width modulated (PWM) design and most current insulated gate bipolar transistors (IGBTs) technology.

2.3 PERFORMANCE REQUIREMENTS

A. Input: 460 (+10%, -15%) VAC, 3 Ph, 60 (± 2) Hz

B. Output: 460 VAC, 3 Ph, 10 to 60 Hz

C. Operating Environment Conditions: Ambient 32°F to 104°F temperature, relative humidity up to 95% non-condensing.

D. Linear acceleration and deceleration adjustable from 5 to 60 seconds. Provide adjustable v/Hz ratio and low speed boost features.

E. Output Current Rating: Continuous full load output current rating of drive shall not be less than that listed for motor of equivalent horsepower in NEC table 430-150.

F. Drive overload capacity to be minimum 110% of motor FLA based on NEC ratings for one minute.

G. Time to Shutdown: Inversely proportional to square of overload current ($t = k/I^2$).

H. Motor Regeneration Protection: Unit shall have capacity of dissipating regeneration energy without damage to or shutdown of drive. Unit shall be capable of starting into rotating load.

I. Output Frequency Stability: ± 0.5% of base frequency in 24 h throughout range of rated operating conditions.

J. Output Voltage Regulation: ± 2% of maximum rated output voltage.

K. Output voltage rise time shall be no faster than 1000 V/micro sec measured at the motor terminals. If power and control cable between VFD and motor is more than 100 ft, provide dv/dt output filter.

L. Power Loss Ride-Through: 3 cycles or 50 milliseconds.

M. Linearity (speed reference to output frequency): ± 1.0%

N. Input Power Factor: Minimum of 0.95 regardless of speed and load.

O. Minimum drive efficiency as percent of input power shall be as follows:

Percent Load	Frequency (Hz)			
	60	50	30	15
100	97	96	95	90

2.4 CONTROL FEATURES

A. VFD speed control circuit shall accept either 4-20 mA DC or 0-10 VDC isolated ungrounded transmitter signal in automatic mode and from manual speed potentiometer in manual mode.

B. Provide adjustable minimum and maximum speed settings (0 - 100%) for both auto and manual mode. Initial minimum setting shall be 25%.

C. Provide adjustable automatic reset for fault trips, except short circuit type faults. After selected number of unsuccessful restart attempts, drive shall be shut down. Number of restart attempts and time interval between resets shall be selective.

D. When unit shuts down due to power outage, unit shall be capable of being restarted manually or automatically.

E. VFD shall be capable of starting into rotating loads spinning in any direction.

F. Provide critical frequency avoidance circuit with at least 3 field adjustable bands to avoid operation at speeds, which cause excessive vibration in driven equipment.

G. Provide isolated ungrounded output signal to indicate drive percent of speed or drive frequency.

H. Provide control for automatically switching from VFD to by-pass line through adjustable time delay relay or equivalent protection whenever VFD shuts down automatically.

2.5 COORDINATION WITH BUILDING AUTOMATION SYSTEM (BAS)

A. Furnish each VFD with BACnet MS/TP digital communication bus card for BAS use. Coordinate with Control Contractor for specific interface requirement. Final connection shall not require any additional intermediate gateway devices to provide throughput of data. The following data shall be provided at a minimum:

1. Fault Condition
2. Speed
3. Motor Run Status
4. VFD Manual/Auto Status
5. Power (kW)

B. Provide contacts (1 NO and 1 NC contact) for remote control of start/stop function for VFD mode and second set for bypass mode if bypass is specified.

C. Provide contacts (1 NO and 1 NC contact) for remote indication of VFD fault condition.

D. One (1) N.O. dry contact output for proving motor status. This output shall be programmed to detect belt or coupling break that would remove the load from the motor. The dry contact will open on loss of load or VFD being off.

2.6 PROTECTION FEATURES

A. Power circuits shall be protected by electronic protection circuits. Electronic protection circuits shall provide orderly shutdown without blowing fuses and prevent component loss under the following abnormal conditions.

1. Instantaneous overcurrent and over voltage trip of output
2. Solid state protective circuit shall provide NEC motor running overload protection tested in accordance with UL Standard 991
3. Power line overvoltage or undervoltage
4. Phase sequence detection or insensitivity to incoming power phase sequence
5. Single and 3 Ph short circuit protection
6. Control circuit malfunction
7. Overtemperature
8. Ground fault for all 3 phases

B. VFD shall protect itself from damage due to phase-to-phase or phase-to-ground faults without fuse blowing or use of isolation transformers. VFD's which require isolation transformers to provide ground fault protection are not acceptable.

C. In addition, provide the following protection features.
   1. Input line-to-line and line-to-ground transient protection up to 3000 V
   2. Control circuit transformer fusing
   3. Grounded control chassis
   4. Diagnostic indication
   5. One set of spare fuses for each type used in drive for each VFD

D. Interlock VFD control circuits with driven motor's disconnect switches where such motor disconnect switches are provided. Disconnecting on-line motor shall shut down VFD. VFD shall restart upon reconnection of motor.

E. VFD shall employ adjustable torque limit control, which shall override speed command and decrease frequency while maintaining correct volts/hertz ratio whenever load level surpasses VFD design level or set point.

2.7 OPERATING AND MONITORING DEVICES

A. The following functionality shall be provided and may be controlled via touchscreen/keypad:
   1. Door interlock to disconnect VFD input power
   2. Manual stop/start device
   3. Operating mode selector device marked "Manual-Off-Automatic"
   4. Manual speed control potentiometer
   5. Power on indication
   6. Drive run indication
   7. Drive fault indication with testable feature
   8. Fault reset device

B. Speed indicating meter or digital indication (0 - 100%) calibrated in percent speed or frequency meter with 0 to 90 Hz scale to indicate motor speed.

C. Integral digital programming and operating display which shows Hz, Percent Output Current, Output Voltage, Percent Output Power, Operating Parameters and their values, and Diagnostic Fault Codes. In addition, Keypads shall be incorporated to facilitate digital programming of drive adjustments. Analog potentiometer adjustments are not acceptable.

D. Provision shall be included to provide selectable programming security by inhibiting program parameter changes with internal dip switch setting or with password security.

E. Control shall incorporate microprocessors for operator interface, diagnostics, and fault managements, and power management.

F. Optional DOS-based programming software, which includes provision for serial communication with drive, shall be available for shipment at time of equipment order placement.

G. Fault buffers to sequentially store last 4 faults. Parameter and fault information to be stored in non-volatile memory.

H. VFD with Manual Bypass Starter:

1. Manual selector switch to select power through VFD or bypass line with label marked "VFD/OFF/BYPASS".
2. Mechanically- and electrically-interlocked VFD/BYPASS contactors with padlocking capability on input side of VFD and bypass starter. Interlock shall be accomplished such that shorting together of any 2 control circuit points can not cause non-selected device to be energized. Provide mechanically- and electrically-interlocked device that connects only output of selected starting device (VFD or bypass starter) to VFD system output lug. Single shorting of any 2 control circuit points shall not cause both VFD and bypass starter outputs to be interconnected.

2.8 QUALITY ASSURANCE TESTS

A. Complete drive assembly shall be factory tested with actual AC induction motor, 100% load and temperature cycled within environment chamber at 104°F. Documentation of test shall be furnished to verify successful completion of test at Engineer's request.

2.9 DISCONNECT DEVICE

A. Provide integral switch to disconnect incoming electrical power to units. Disconnect device shall be UL Listed device of the following:

1. Motor circuit switch: horsepower rated
2. Enclosed molded case breaker; ampere rated and providing over current protection
3. Molded case switch; ampere rated enclosed switch with or without over current protection
4. Rotary switch: with or without fuser

B. Unit shall have an interrupting rating not less than that of the upstream overcurrent device as shown on electrical drawings.

C. Disconnect shall be capable of being padlocked in OFF position and complying with OSHA Requirements. Operating handle shall indicate whether switch is “ON” or “OFF”.

D. Switch shall have dual cover interlock to prevent unauthorized opening of switch door when handle is in “ON” position and to prevent closing of switch mechanism with door open. Provide defeater mechanism to defeat the interlock for user required access.

2.10 MOTOR CONTROL EQUIPMENT (BYPASS STARTERS)

A. Bypass starter shall be NEMA or IEC Rated device of the following:

1. Electromechanical across-the-line starter with solid state overload protection for 50 hp or smaller.
2. Solid-state reduced voltage starter consisting of SCR based power section, logic control board and solid state overload protection for 60 hp or larger.
3. Reduced voltage auto transformer - electromechanical starter with solid-state overload protection for 60 hp or larger.

2.11 LINE REACTORS (WHERE REQUIRED BY IEEE 519 STUDY)

A. Series line reactors shall be designed for harmonic filtering service and shall be UL component recognized. Construction shall be copper wire wound on steel cores. Inductors shall be 3-phase. Series line reactors shall be sized at 3% impedance and appropriately for total connected load. Design maximum temperature rise for inductors shall be 115°C.

B. Core shall be made of laminated grain oriented electrical steel (grade M6 or better). Brackets shall be ASTM structural steel or structural aluminum. Coils shall be wedged in place and core locked in place using vertical ties or rods.

C. Windings shall be copper wire, MW35C (round) or MW36C (rectangular) or copper foil. Terminations shall be tin plated copper alloy ring lugs, UL recognized terminal blocks, or solid copper bus. Terminations shall be pressure crimped or TIG welded to windings. Sheet insulation shall be DuPont Nomex 410 of thickness meeting UL insulation systems.

D. Inductors shall be double impregnated (vacuum/pressure impregnate and bake followed by varnish dip and bake). Insulation systems shall be rated Class H (180°C), 600 V. Inductors shall be Hi-Pot tested (2500 V, 60 Hz, 1 minute) line-to-line and line-to-ground.

E. Inductors shall be air-gapped to avoid saturation. Inductance shall be measured under full load and shall be within ± 5% of design value.

F. Line reactor shall be included integral to drive enclosure.

1. Where mounting line reactor in VFD enclosure is not possible, enclosure shall be steel with enamel finish and no knockouts. Enclosure shall match construction of VFD enclosure and shall have hinged lockable cover. Screened openings shall be provided for enclosure ventilation. Enclosure shall be built with integral mounting brackets for platform or wall mounting. Coordinate location with other trades.

2.12 OUTPUT LC FILTER (WHERE REQUIRED BY IEEE 519 STUDY)

A. Output LC filter shall consist of gapped, three phase, iron core inductor; AC-rated polypropylene capacitors; and wire-wound resistors. Filter shall be rated for application at maximum fundamental system frequency of 60 Hz at nominal system voltages up to 600 V. Filter shall operate at maximum carrier frequency of 8 kHz at 40% of fundamental voltage. Ambient temperature of operation shall be 104°F.

B. Three phase inductors shall be designed for harmonic filtering service and for slowing rate of rapid current changes. Inductors shall be UL component-recognized and shall be built to comply with UL 508A Standard. Construction shall be of copper wire wound on magnetic grade steel. Inductors shall be sized appropriately for total connected load. Design maximum temperature rise for reactors shall be 239°F at rated current.

C. Core shall be made of laminated grain-oriented electrical steel (grade M6 or better). Brackets shall be ASTM structural steel or structural aluminum. Coils shall be wedged in place and core shall be locked in place using vertical ties or rods.

D. Windings shall consist of copper wire or of copper foil. Terminations shall be copper alloy ring lugs, UL-recognized terminal blocks, or solid copper bus. Sheet insulation shall be DuPont Nomex 410 of thickness as required for UL insulation systems.

E. Inductors shall be air-gapped to control saturation. Inductance shall be measured under full load and shall be within 10% of design value.

F. Completed inductors shall be impregnated with 100% solid epoxy resin. Insulation varnish systems shall be rated Class H (180°C), 600 V.

G. Filter shall be housed internal to drive enclosure.

2.13 ISOLATION TRANSFORMERS

A. Provide isolation transformer similar to Square D DIT type. Size transformer based on maximum kVA load of connected motor and in accordance with VFD manufacturer's recommendations.

B. Three phase transformers shall be 60 Hz, 480 V delta primary and 480Y/277 V secondary.

C. Transformers shall be air cooled, 2 winding type with minimum of four 2-1/2% full capacity primary taps, 2 above and 2 below full rated primary voltage.

D. Transformers 25 kVA to 112.5 kVA shall have 239°F temperature rise above 104°F ambient, allowing 15% continuous overload without exceeding 150°C rise in same ambient. Transformers above 112.5 kVA shall have temperature rise of 176°F above 104°F ambient, allowing 30% continuous overload without exceeding 302°F rise in same ambient.

E. Insulating material shall be in accordance with NEMA ST20 standard for 220°C UL component recognized insulation system.

F. Maximum temperature at top of enclosure shall not exceed 122°F rise above 104°F ambient.

G. Ventilation opening shall be designed to prevent accidental access to live parts.

H. Transformer coils shall be continuous wound construction and shall be impregnated with non-hygroscopic, thermosetting varnish.

I. High grade silicon steel, non-aging with high magnetic permeability, low eddy current loses and low hysteresis is required of cores. Magnetic flux densities shall be below saturation point. Core laminations shall be clamped securely with sturdy steel members.

J. Provisions shall be made to isolate core and coil from enclosure with no metal-to-metal contact. Rubber vibration absorbing mounts shall be used to isolate base of enclosure from core and coil assembly.

K. Visibly ground transformer neutral to enclosure with flexible grounding conductor.

L. Entire transformer enclosure shall be degreased, cleaned, phosphatized, primed, and finished with baked enamel.

M. Provide grounded shield between primary and secondary windings. Electrostatic shield shall consist of one-turn strip-copper winding placed between transformer primary and secondary winding. Insulate ends to prevent shorting. Lead from one end of shield shall run to transformer enclosure for grounding. Electrostatic shield shall not change primary and secondary winding insulation level to ground.

2.14 SPARE PARTS

A. Additional enclosure cooling fan for each different type of drive.

B. Additional key pad/touch screen for each different type of drive.

PART 3 - EXECUTION

3.1 INSPECTION

A. Visually inspect equipment and components at time of delivery. Submit report to Engineer with list of items or deficiencies to be corrected.

3.2 PROTECTION

A. Protect VFD cabinets from dust/dirt during storage and operation until turned over to Laboratory.

B. If VFDs are not furnished with internal air filter racks, provide temporary filter media to protect VFD cabinets and replace filter media as required.

3.3 INSTALLATION

A. Install VFD system in accordance with details, approved Shop Drawings and manufacturer's instructions and recommendations.

B. Provide field low voltage wiring of VFD system components. Provide field interconnecting wiring between VFD and by-pass starter if bypass starter is specified and the wiring is not installed at factory. Install wiring in metal conduit and in accordance with Electrical sections of this Specification and applicable Electrical Code.

C. Provide control wiring between interlocks in VFD control circuits and driven motor's disconnect switches, where such motor disconnect switches are provided.

D. Do not connect ground from one unit to another unit's cabinet.

E. Use separate conduits for incoming and outgoing power conductors from each unit.

F. Use separate conduit for control wiring for each unit. Control wiring shall not occupy same conduit as power wiring.

G. Use minimum 18 ga shielded wiring with ground for control wiring.

H. Install floor mounted drives on 3-1/2” high concrete housekeeping pad.

I. Isolation Transformers:

1. Unless otherwise indicated, transformers below 75 kVA shall be wall or ceiling mounted. Transformers 75 kVA and above shall be floor mounted. Ample space shall be allowed for air circulation around all sides. Do not mount transformers below VFD equipment. Mount transformers above if conditions are tight.
2. Make all connections through enclosure at sides near bottom with vinyl covered flexible metal conduit in lengths not to exceed 3 ft.

3.4 START UP

A. Perform start-up of VFD in accordance with procedures as defined by manufacturer for proper operation.

B. Adjust critical frequency avoidance feature to step over frequencies which cause excessive vibration in driven equipment.

End of Section

SECTION 20 05 20

EXCAVATION AND BACKFILL

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section lists methods and materials for trench excavation and backfill for plumbing piping systems inside and outside the building.

1.2 RELATED WORK

A. Division 31 - Earthwork

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions of Contract, Supplementary Conditions, and sections under Division 01 General Requirements.

1.4 SUBMITTALS

A. List of materials to be used for backfill.

PART 2 - PRODUCTS

2.1 FILL MATERIAL

A. Type 1 Fill:
   1. Material from excavation separated from materials, which do not compact by tamping and rolling. No stones larger than 3” and no building, organic, corrosive or frozen materials.

B. Type 2A Fill:
   1. Sand or gravel materials with none larger than 2” and of that portion passing #4 sieve less 5% to pass #200 sieve.

C. Type 2B Fill:
   1. Sand or gravel materials with none larger than 1/2” and of that portion passing #4 sieve less 5% to pass #200 sieve.

D. Type 3 Fill:
   1. Gravel of rounded to subangular shape, screened, which will pass 0.75” sieve and retained on #4 sieve.

E. Type 4 Fill:
   1. Pit run rock or gravel with maximum stone size of 1”.

F. Type 5 Fill:
   1. Pea gravel, screened, which will pass 0.375” sieve and retained on #4 sieve.

G. Type 6 Fill:
   1. Soils Engineer approved fill material, backfilled and compacted beneath building footprint.

PART 3 - EXECUTION

3.1 PREPARATION

A. Establish grade lines and locations of mains and manholes. Provide necessary stakes and batter boards.

B. Verify invert elevations of existing utilities prior to excavation for new utility piping.

3.2 EXCAVATION

A. Provide excavation for all underground work, including piping, manholes, catch basins, tanks, concrete structures, etc., unless otherwise shown or specified. Lay piping in open trench except when Architect gives written permission for tunneling.

B. Include all necessary clearing; tree removal; grubbing; pavement removal; substructure removal such as walls, footings and piers and all incidental work such as tunneling, sheet piling, shoring, underpinning, pumping, bailing and transportation. Coordinate excavation extending beyond construction limits with Construction Manager and Laboratory.

C. Blasting is not allowed on this project without written permission of Architect and Laboratory.

D. Remove all excess excavation material from site unless directed otherwise.

E. Use mechanical methods to remove rock in trenches for piping systems.

F. Include rock excavation in the Bid unless otherwise indicated.

3.3 PIPE INSTALLATION

A. Keep underground piping to proper line and grade and sealed at all times to prevent entrance of animals or foreign matter.

B. Provide bracing and sheet piling as necessary to support trenches. Comply with Local Regulations, applicable provisions of OSHA Regulations on trenching, or with provisions of “Manual of Accident Prevention in Construction” published by Associated General Contractors of America.

C. Under no circumstances lay pipe or install appurtenances in water. Keep trench free from water until pipe joint material has hardened.

D. Presence of ground water in soil or necessity of sheet piling or bracing trenches shall not constitute condition for which any increase may be made in Contract price, except when sheet piling is left in place on written order of Laboratory, Contract price will be adjusted.

E. Cut off sheet piling left in place not less than 2” below new finished grade. Do not remove sheet piling until trench is substantially backfilled.

F. Place underground piping outside and inside building in open excavated trenches. Where trench bottom does not contain stones larger than 1” in size or where bedrock is not encountered, trench may be excavated to final pipe grade. Where bedrock or stones larger than 1” is encountered, excavate entire length of trench to depth 4” below final pipe grade elevation and provide 4” of pipe bedding material compacted to minimum of 90% Standard Proctor Density consisting of Type 2B, 3 or 5 fill to establish final pipe grade. Shape bedding for clearance for all joints and fittings, tamped in place and graded evenly to insure uniform bearing for full length of pipe. Do not support piping by blocking, planking or mounding of bedding material.

3.4 BACKFILL

A. Exterior:

1. Backfill outside building including all piping beyond construction limits only after piping and appurtenances have been inspected, recorded, tested and approved. Backfill around pipe by hand to depth of 12” above top of pipe with Type 2B, 3 or 5 fill in 6” layers. Take care not to disturb pipe or damage pipe coating. Do not use Type 3 fill where it will come in contact with polyethylene encasement. Compact backfill thoroughly with compactor of suitable weight or with approved mechanical tamper. No flooding or jetting with water is allowed.
2. Place backfill from 12” above pipe in layers not exceeding 8” in depth with Type 1 fill. Compact backfill material to the same density as surrounding area prior to that of excavation.
3. When excavating through areas which are to become walks, roads, driveways or parking areas of concrete, bituminous or exposed gravel surfacing or such areas are existing to remain; backfilling from 12” above pipe to subgrade shall be with Type 2A, 2B, 3 or 4 fill. Backfill in 12” layers and compact with mechanical means to density 95% modified proctor. Frequency of compaction testing shall be determined by testing consultant, based on site conditions, materials and workmanship.
4. When excavation occurs on public property or areas beyond property line, all excavation, pipe laying, backfilling, grading and surfacing shall conform as herein specified, except additional requirements for public utility or other authorities shall be complied with when in order. Check with each utility and incorporate cost of any additional requirements in Base Bid.

B. Interior:

1. Backfill inside building only after piping and appurtenances have been inspected and approved. Backfill to 12” above pipe with Type 2B, 3 or 5 fill in 6” layers. Remainder of backfill shall be Type 2A, 2B, 3, 4, or 6 fill in 12” layers.
2. Install lines passing under foundations with minimum of 1-1/2” clearance to concrete and insure there is no disturbance of bearing soil.

3.5 ROCK EXCAVATION

A. Consider material over one cubic yard in size encountered during excavation as rock. Rock excavation will be paid as extra if it cannot be removed by 200 net hp crawler tractor with ripper attachment all in good running condition and operated by an experienced individual.

B. Excavate rock to 4” below intended pipe invert.

3.6 FINISHING

A. On completion of trenching and backfilling operations, restore grades to original elevation or to new subgrade elevation.

B. When trenching is through existing areas or beyond constructions limits, replace surfaces to existing conditions.

C. In landscaped areas use 6” of topsoil and sod to match existing elevations, or as otherwise approved by Landscape Architect.

End of Section

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SECTION 20 05 29

MECHANICAL SUPPORTING DEVICES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 07 00 - Mechanical Systems Insulation

B. Section 23 05 50 - Vibration Isolation (Spring Hangers and Mounts)

C. Section 23 31 14 - Ductwork (for additional duct supports requirements)

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Provide all supporting devices as specified and as required for proper support of piping, ductwork, equipment, materials and systems.

B. Support for all conditions of operation, including variations in installed and operating weight of equipment, piping and ductwork, to prevent excess stress and allow for proper expansion and contraction.

C. Support of fire protection pipe shall comply with NFPA 13, Installation of Sprinkler Systems, 2007 Edition.

1.4 SUBMITTALS

A. Shop Drawings for each piping system for all pipe sizes and all applicable equipment including, but not limited to, the following:

1. Manufacturer's name
2. Model numbers
3. Materials of construction and load ratings (lbs)
4. Schedule of hangers and support devices with pipe support spacing
5. Insulated pipe supports along with application chart or table
6. Insulation protection saddles and weight bearing insulation table
7. Details and calculations for sizing supplementary steel utilized for trapeze or specially designed supports
8. Structural attachments, inserts and concrete anchors
9. Calculations and drawings for concrete anchors for each application
10. Drawings showing specific locations of any weld attachments to structure, including weight supported by such attachments
11. Equipment mounting devices
12. Pipe guides and anchors
13. All other appropriate data

14. Where loads imposed exceed design superimposed dead loads or suspended loads specified in contract documents, submit for approval to Structural Engineer of Record loads imposed on the primary structural frame. Submittal shall include location, magnitude and direction of imposed loads (basic, unfactored load cases), graphically represented in their appropriate locations on a copy of the Contract Document structural framing plans or elevations as appropriate. Detail references indicating the connections applicable at each location shall be noted on the submittal drawings.

1.5 DESIGN CRITERIA

A. Materials and application of pipe hangers and supports shall conform to latest requirements of ANSI/ASME Code for Pressure Piping B31.1 and MSS Standard Practice SP-58 (Materials, design and Manufacture), SP-69 (Selection and Application), and SP-89 (Fabrication and Installation Practices), except as supplemented or modified herein.

B. Support materials shall be steel or stainless steel unless specifically indicated.

C. Support devices shall be factory fabricated by manufacturers and have published load ratings.

D. Unless otherwise indicated, design structural support members and support devices, including couplings, rods, trapeze supports and strut systems, with safety factor in accordance with AISC Manual of Steel Construction, but not less than 2.0.

E. Determine maximum deflection using the following equation.

$$D = \frac{H \text{ or } L}{250}$$

WhereD = Max deflection in millimeters
H = Member height in inches
L = Member length in inches

F. Unless otherwise indicated, hangers, support devices and hardware shall be steel and shall have factory standard black, primed, galvanized or electroplated finish for indoor application, and hot-dipped galvanized finish for outdoor application and corrosive atmospheres. Coat cut edges, welds or any damaged finish with galvanized paint.
   1. Corrosive atmospheres include the following locations:
      a. Exterior locations
      b. Chemical storage and hazardous waste storage rooms
      c. Locker/shower rooms
      d. Sterilizer/autoclave room

G. Material in contact with pipe shall be compatible with piping material so that neither shall have deteriorating action on the other. If materials such as copper, stainless steel or other materials are not compatible, provide nonmetallic separation between uninsulated piping and metal supports. Plastic coated steel supports are acceptable.

H. Unless otherwise indicated, steel support devices exposed to ventilation air stream shall be stainless steel or steel with either galvanized finish or paint finish. Paint type shall be approved by Architect/Engineer.

I. This Contractor is responsible for proper placement and sizing of supporting devices to accommodate insulation thickness and pitching of pipe. Coordinate with Contractor performing work specified in Section 20 0700 - Mechanical Systems Insulation.

J. In addition to hangers specified in this Section, piping connected to pumps, compressors, and similar rotating or reciprocating equipment shall have vibration isolation hangers or supports for distance of 100 pipe diameters or 50 ft away from equipment, whichever is greater.

K. Piping connected to coils, which are in assembly mounted on vibration isolators, shall have flexible piping connections and vibration supports as indicated above. Piping connected to coils, which are in equipment where fan assembly is separately isolated by means of vibration isolators and duct flexible connections does not require additional spring vibration supports. Flexible connections and vibration isolators are specified in Section 23 0550 - Vibration Isolation.

L. Where piping can be conveniently grouped to allow trapeze type supports, supporting steel shall be by means of standard structural shapes.

M. Hangers and rods shall be plumb when pipelines are at their normal operating temperatures.

N. Unless otherwise indicated, continuous insert channels are not allowed.

O. Punching, drilling, or welding of building structural steel is not allowed unless approved in writing by Structural Engineer.

P. Application of concrete inserts and concrete anchors shall be reviewed and approved by Structural Engineer prior to installation.

Q. Any proposed weld attachments to building structure shall be reviewed by Structural Engineer prior to execution of work. This review may result in use of other welding codes or standards, which may apply to "structural work". Execution of this work may be assigned to General Trades responsible for building structural steel. Cost for this work, however, will remain the responsibility of this Contractor.

PART 2 - PRODUCTS

2.1 STRUCTURAL SUPPORTS

A. Provide all supporting steel, not indicated on structural drawings, that is required for installation of mechanical equipment and materials, including angles, channels, beams, etc. to suspend or floor support equipment.

2.2 PIPE HANGERS AND SUPPORTS (METALLIC)

A. Manufacturers: Anvil (formerly Grinnell), Erico, Tolco, National Pipe Hanger Corporation, or B-Line, equal to Anvil figures listed. Corresponding MSS Type is indicated where applicable.

B. Hangers/supports for copper pipe where supports directly contact to pipe shall be either copper plated or PVC coated.

C. For insulated pipe supports, refer to Insulated Pipe Supports in Part 3 of this Section.

D. Clevis and Roller Type Hangers:

System	Pipe Size	Clevis	Roller
Hot Pipes with Insulation (120°F and above)	2” and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2” to 6”	---	171 (MSS Type-41), 181 (MSS Type-43)

System	Pipe Size	Clevis	Roller
Ambient Bare Pipes (60°F to 119°F)	2” and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2” and larger	260 (MSS Type-1), 216 (MSS Type-4)	---
Cold Pipes with Insulation (33°F to 59°F)	2” and larger	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2” and larger	260 (MSS Type-1), 295 (MSS Type-1)	---

1. For pipe size 2-1/2” and larger, where there is transverse movement at support points due to thermal expansion/contraction, clevis type hangers similar to Anvil Figure 260 (MSS Type-1) may be used if vertical angle of hanger rod is less than 4°.

E. Flat Surfaces (Trapeze, Rack Type):

1. Use structural steel members such as struts, angles, channels and beams to support pipes as required. Select members properly for pipe support types and loading conditions. Refer to Part 1 for design criteria. Submit support details with type of members selected and load calculations. Provide straps, clamps, rollers or slides indicated below at each support point.

System	Pipe Size	Straps or Clamps	Rollers	Slides
Hot Pipes with Insulation (120°F and above)	2” and smaller	243, 244	---	---
	2-1/2” and larger	---	177, 271 (MSS Type-45), 274 (MSS Type-46)	257 or 436 with 212 or 432 clamps, Type 1, 2 or 3 for longitudinal movement only and Type 4, 5 or 6 for both longitudinal and transverse movement of piping.
Ambient Bare Steel Pipes (60°F to 119°F)	6” and smaller	B-Line BVT	---	---
	8” and larger	137 (MSS Type-24)		
Ambient Bare (Copper) pipes (60°F to 119°F)	all sizes	B-Line BVT		
Cold Pipes with Insulation (33°C to 59°C)	10” and smaller	137 (MSS Type-24)	---	---

2.3 INSULATION PROTECTION SHIELDS

A. Anvil Fig. 167 (MSS Type-40) constructed of galvanized carbon steel. Per the latest edition of Standard MSS SP-58, select shield to accommodate outer diameter of insulation. Shield length and gauge for insulation compression strength not less than 103 kPa, shall be as follows:

Pipe Size	Length	Gauge
1/4” thru 3”	12”	18
4”	12”	16
5” and 6”	18”	16

2.4 INSULATION PROTECTION SADDLES

A. Anvil Fig. 160 Series (MSS Type-39) constructed of carbon steel or alloy steel plate. Select saddles to accommodate insulation thickness specified in Section 20 0700 - Mechanical Systems Insulation.

2.5 WEIGHT BEARING INSULATION INSERTS

A. Insert thickness shall match pipe insulation thickness. Pipe insulation jackets shall be continuous through sections containing inserts.

B. Minimum length of inserts shall be 12” or 2” longer than insulation protection shields, whichever is longer. Quantity and placement of inserts shall be based on weight of pipe and fluid plus 1.5 safety factor.

C. Hot Pipes (120°F and above):

1. High-density calcium silicate insulation (Type H) similar to Johns Manville Thermo-12 or cellular glass insulation (Type G) similar to Pittsburgh Corning Foamglas. Maximum compression strength for load calculation shall be 100 psi.
2. HAMFAB H-Block by ICA Inc. may be used. Maximum compression strength for load calculation shall be 30 psia.

D. Cold Pipes (59°F and below):

1. Cellular glass insulation (Type G) similar to Pittsburgh Corning Foamglas, maximum compression strength 100 psi, Koolphen K insulation by Kooltherm Insulation,5-lb/ft3, maximum compression strength 50 psi, or HAMFAB H-Block by ICA Inc., maximum compression strength 30 psi. H-Block inserts shall be coated with vapor barrier coating similar to CADALAR 670 by SKIRGES Corp.

2.6 PRE-INSULATED PIPE SUPPORTS

A. Pipe Shields, Inc., Bergen Pre-Insulated Pipe Supports, Rilco, or Tri-State Industries equal to Pipe Shields models listed

B. Insulation shall consist of water-resistant calcium silicate of same thickness as adjoining pipe insulation, thermal conductivity not more than (0.38 Btu·in/(hr·ft^2·°F) at 75°F mean temperature, minimum density of (13 lb/ft^3), and compressive strength not less than 100 psi.

C. Structural inserts shall be water-resistant, high-density calcium silicate with minimum density of (32-lb/ft^3).and minimum compressive strength of 600 psi. Structural inserts shall be used as recommended by manufacturer to meet load ratings.

D. Use vapor barrier steel jacket around insulation. Insulation jackets shall be galvanized steel conforming to ASTM A-527. Hanger bearing surface shall consist of galvanized sheet metal insulation protection shield or casing.

E. When recommended by manufacturer, use double layer insulation protection shield at support bearing surface. Insulation shall extend 1” beyond insulation protection shield to maintain vapor barrier integrity.

F. Pre-insulated pipe supports shall be load rated. Load ratings shall be established by pipe support manufacturer based upon testing and analysis in conformance with the latest edition of the following codes and standards: ASME B31.1, MSS SP-58, MSS SP-69, and MSS SP-89.

G. Load tests shall be made on both supporting materials and configurations. All tests shall be performed by independent testing laboratory. Results of pertinent tests shall be available upon request.

H. Unless otherwise indicated, pre-insulated pipe supports shall be as indicated in the following schedule. Model numbers are based on Shaw Pipe Shields, Inc.
   1. Pipe supported on hangers: Models A2000, A4000, A9000, D3000 and D3200
   2. Pipe supported on flat surfaces: Models A2000, A4000, A6000, A7000, A7200, and A7400
   3. Pipe supported on pipe rolls: Models A4000, A6000, A8000, A8200, and A8400
   4. Pipe supported on slides: Model "B" Series
   5. A1000, A3000 or A5000 may be used for hot pipes (120°F and above)

I. Select proper model to conform to pipe service, support style, and support spacing.

J. Submit chart or table indicating selected model along with pipe sizes, rated loads, support device types and support spacing for each piping system.

K. Pipe support spacing shall be in accordance with manufacturer's recommendations, but in no case shall exceed maximum spacing indicated under Hanger and Support Spacing in Part 3 of this Section.

2.7 HANGER RODS (METALLIC)

A. Rods shall conform to the latest MSS Standards except as modified herein. Furnish rods complete with adjusting and lock nuts.

B. Rods shall have electroplated zinc or hot dip galvanized finish.

C. Unless otherwise indicated, size rods for individual hangers and trapeze support as indicated in the following schedule. Rod size may be reduced one size for double rod hangers. Total weight of equipment, including valves, fittings, pipe, pipe content and insulation, shall not exceed limits indicated. If hanging/suspended loads exceed design superimposed dead loads or suspended loads specified in contract documents, comply with loads imposed requirement in Part 1 – Submittals.

Max. Pipe Size With Single Rod	Rod Diameter (inches)	Max Load (lbs) of Hanger Rod (Not exceeding 650°F Service Temp.)
2”	3/8	730
3”	1/2	1350
5”	5/8	2160
8”	3/4	3230

2.8 BOLTS, NUTS, STUDS AND WASHERS

A. ASTM A307, electroplated zinc finish

2.9 ROD ATTACHMENTS

A. Anvil Fig. 290 (MSS Type-17), galvanized finish

2.10 U-BOLTS

A. Anvil Fig. 137 (MSS Type-24), galvanized finish

2.11 BEAM CLAMPS

A. Beam Clamps: Anvil Fig. 133/134 (MSS Type-21), 218 (MSS Type-30), 228 (MSS Type-28 or 29) and 292 (MSS Type-28 or 29)

B. Top Beam Clamps: Anvil Fig. 227 (MSS Type-25)

C. C-Clamps: Anvil Fig. 86, 92 or 93 (MSS Type-19 or 23) with set screw and lock nut

2.12 ADJUSTABLE PIPE SADDLE SUPPORTS

A. Anvil Fig. 264 (MSS Type-38)

2.13 RISER CLAMPS

A. Anvil Fig. 261 (MSS Type-8), galvanized finish

B. Anvil Fig. CT-121, copper plated carbon steel, plastic coated in area at pipe contact, for bare copper tubing

C. Proset system, proseal plug and fire-fill for sleeved and cored holes.

2.14 CONCRETE INSERTS (WOODEN FORMED CONCRETE)

A. Anvil Fig. 281 or 282 (MSS Type-18), suitable for rod diameter and weight supported.

2.15 CONCRETE INSERTS (METAL DECK FORMED CONCRETE)

A. Anvil Fig. 284, Tolco No. 109 A, B-Line Fig. B3019, Powers Fasteners "Bang-It", or MSCO No. MX34.

2.16 CONCRETE ANCHORS (STATIC/GRAVITY LOADS ONLY, NOT FOR SEISMIC LOADS)

A. Manufacturers: Hilti, Powers Fasteners or Red Head

B. Anchors shall meet ICC Acceptance criteria, and ICC-ESR reports shall specifically list the current applicable codes.

C. Anchors shall be designed and detailed by Structural Engineer registered in project’s jurisdiction. Calculations and drawings shall be submitted.

D. Flush or shell type, meeting description in Federal Specification FF-S-325, Group VIII, Type 1 for expansion shield anchors, similar to Hilti Kwik Bolt TZ, Powers Power-Stud+SD1, Power-Stud+SD2, or Snake+. Anchors shall be zinc plated in accordance with ASTM B633.

E. Select anchors with load ratings based on cracked concrete conditions.

F. Anchors installed in hardened concrete for purpose of transmitting structural loads from one connected element to another, or for safety related elements such as sprinkler pipes, heavy suspended pipes, and barrier rails shall have ICC-ESR report demonstrating anchors have met requirements of AC 193 for mechanical anchors.

2.17 CONTINUOUS INSERT CHANNELS

A. Manufacturers: Unistrut, Anvil, B-Line, Michigan, Halfen or Kindorf. Brackets inserts and accessories shall be suitable for channel insert selected.

B. Length and support capabilities to be suitable for supporting plumbing piping in vicinity.

2.18 METAL FRAMING SUPPORT SYSTEM (STRUT SYSTEM)

A. Manufacturers: Unistrut, B-Line Strut Systems, Power-Strut, Erico, Superstrut, Kindorf, and Hydra-Zorb

B. Channels shall have epoxy paint or electroplated zinc finish.

C. Channels shall not be lighter than 12 ga.

2.19 PIPE MOUNTING PEDESTALS

A. Equal to Roof Products & System Corporation consisting of equipment rail, "U" shaped mounting brackets, galvanized threaded rod and cast iron pipe rollers. Rail shall have built-in raised cant to match roof deck insulation.

2.20 EQUIPMENT RAILS

A. Manufacturers: Roof Products & Systems, ThyCurb, Custom Curb, Inc. or Vent Products equal to Roof Products & Systems Model ER-4 with raised cant style. Mounting rails shall be galvanized steel with integral base plate, continuous welded corner seams, factory installed 2x4 wood nailer and 18 ga galvanized steel counter flashing.

B. Mounting rail gauge shall be selected to support equipment adequately but shall be not less than 18 ga.

C. Height shall be as detailed, but not less than 8” above finished roof.

D. Equipment rails shall span minimum of 2 joists and not cantilever more than 6” where joists are used. Rails shall be level at top with pitch built in when deck slopes 1/4” per foot or greater.

2.21 PIPE ROOF PENETRATION PROTECTIONS

A. Manufacturers: Roof Products & Systems, ThyCurb or Vent Products equal to Roof Products & Systems "RPS-Pipe Portals" consisting of 12” OD prefabricated roof curb, laminated acrylic coated ABS plastic curb cover with EPDM protective rubber cap and stainless steel clamp.

2.22 PIPE GUIDES

A. Unless otherwise indicated, guides shall be Pipe Shields, Bergen Pre-Insulated Pipe Supports, or Rilco equal to Pipe Shields "B" Series B3000, B4000, B7000, B8000, selected by load and movement.

2.23 PIPE ANCHORS

A. Unless otherwise indicated, anchors shall be no-moment type, Shaw Pipe Shields or Rilco equal to Shaw Pipe Shields Insulated Positive Pipe Anchor Model C3000 or C4000 Series, sized to meet anchor forces shown with minimum safety factor of 3.0.

B. Contractor may fabricate anchors of steel sections suitable for location of installation and for withstanding anchor forces shown with minimum safety factor of 3.0.

2.24 CASEWORK PIPE SUPPORTS

A. Hinged pipe clamp and Strutcatcher, nylon 12 Grilamid, Clic by Litchfield International.

B. Vibration isolation pipe clamp, yellow zinc chromate finish, B-Line BVT Series Vibraclamp or Kwik-Clip by B-Line.

2.25 FIXTURE SUPPLY SUPPORT

A. Galvanized steel stud support bracket, pre-drilled tube support mounting holes, adjustable stud width, Erico TSGB or equal.

B. UV resistant nylon tube support, rated for 0°F through 130°F, resealable locking mechanism, Erico TPC or equal.

C. Support bracket and tube support to be from same manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install supports to allow for free expansion of piping. Support piping from building structural members using concrete inserts, beam clamps, ceiling plates, wall brackets, or floor stands. At no time shall hangers and supports overload building structural members. Fasten ceiling plates and wall brackets securely to structure and test to demonstrate adequacy of fastening.

B. Select and size building attachments properly in accordance with MSS Standards and manufacturer's published load rating information.

C. Coordinate hanger and support installation to properly group piping of all trades.

D. Suspend hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.

E. Piping and ductwork shall be supported independently from other piping or ductwork.

F. Pipe hangers and supports shall not penetrate vapor barrier of pipe insulation.

G. Do not support equipment, piping or ductwork from metal roof decking or ceiling grid.

H. Install adequate supports during erection of piping so as not to over stress either piping or equipment to which piping is connected.

I. Refer to Section 20 0000 - General Mechanical Requirements for requirements of personnel injury protection guards for supporting devices.

3.2 HANGER AND SUPPORT SPACING

A. Space pipe hangers and supports for horizontal pipe accordance with the following schedule, with exceptions as indicated herein:

1. If hanging/suspended loads exceed design superimposed dead loads or suspended loads specified in contract documents, comply with loads imposed requirement in Part 1 – Submittals.

B. Steel Pipe (Standard Weight and Extra Strong):

Pipe Size	Max Spacing
1-1/4” and smaller	7’-0”
1-1/2”	9’-0”
2”	10’-0”
2-1/2”	11’-0”
3”	12’-0”
4”	14’-0”

6”	17’-0”
8”	19’-0”
10” and larger	20’-0”

C. Copper Tube (Unless Otherwise Noted):

Pipe Size	Max Spacing
3/4” and smaller	5’-0”
1” to 1-1/4”	6’-0”
1-1/2” to 2-1/2”	8’-0”
3” and larger	10’-0”

D. Copper Tube (Domestic Water, Laboratory Water, Non-potable Water):

Pipe Size	Max Spacing
1-1/4” and smaller	6’-0”
1-1/2” and larger	10’-0”

E. Copper Tube (Domestic Water, Laboratory Water, Non Potable Water):

Pipe Size	Max Spacing
1-1/2” and smaller	6’-0”
2” and larger	10’-0”

F. Copper Tube (Medical Gases):

Pipe Size	Max Spacing
1/4”	5’-0”
3/8” and 1/2”	6’-0”
3/4”	7’-0”
1”	8’-0”
1-1/4”	9’-0”
1-1/2” and larger	10’-0”

G. Plastic Pipe

1. PVC Pipe:

Pipe Size	Max Spacing
All sizes	4-0”

2. CPVC Pipe:

Pipe Size	Max Spacing
1” and smaller	3’-0”
1-1/4” and larger	4’-0”

3. PVDF Pipe (Waste and Vent):

Pipe Size	Max Spacing
2” and smaller	2” and smaller
3” and larger	3” and larger

4. PP Pipe (Waste and Vent):

Pipe Size	Max Spacing
1-1/2” and smaller	4’-0”
2”	4’-6”
3”	5’-0”
4”	6’-0”

5. PP Pipe (High Purity Water):

Pipe Size	Max Spacing
All sizes	Continuous sheet metal trough

6. Support plastic pipe at all changes of direction. Adequate consideration shall be given to piping expansion.

H. Cast Iron Pipe:
1. Maximum hanger and support spacing shall be 10 ft. for all pipe sizes. Provide minimum of one hanger per pipe section close to joint on barrel, at each pipe fitting, at change of direction and branch connections.
2. Support Cast Iron No-Hub pipe as recommended in CISPI Publication "Cast Iron Soil Pipe and Fittings Handbook, Chapter IV - Installation of Cast Iron Soil Pipe and Fittings."

I. Borosilicate Glass:
1. Maximum hanger and support spacing for borosilicate glass piping shall be 10 ft.
2. Support borosilicate glass pipe with padded hangers.

J. Maximum spacing shown above may be restricted by strength of attachment to building structure. Submit data with calculations with published load ratings showing attachment to be utilized and maximum spacing allowable for that type of attachment and pipe size.

K. Spacing less than indicated above may be required to conform to building structure design or loading limitations.

L. If pipe size changes between support points, maximum spacing shall be based on the smaller pipe size.

M. If trapeze hangers are used to support multiple services, spacing shall be based on the most restrictive pipe size and material on trapeze hanger.

N. For non-metallic pipe, follow manufacturer's installation recommendations in addition to requirements noted herein.

O. Install supports for vertical piping and anchors as recommended by pipe manufacturer.

P. Place hangers and supports to meet requirements of Section 23 2116 - Pipe and Pipe Fittings or specific pipe system sections, with regard to pitch for drainage and venting and clearance between services.

Q. Hangers and supports shall bear on outside of insulation when pipes are to be insulated.

R. Place hangers and supports within 1 ft of either side of each fitting, such as elbows and tees, and at each valve, strainer, and other piping specialty for piping 4” and larger.

S. Place hanger or support at first elbow upstream of pump inlet and first elbow downstream of pump outlet.

3.3 RISER SUPPORTS

A. Insulated Piping and non-insulated piping (120°F and above):

1. Unless otherwise indicated, support vertical piping as indicated below:
2. Support vertical piping at bottom of riser, secured and anchored to building structure. Provide guides on vertical piping. Use spring hangers at top of riser and at take offs from riser at each floor. Use spring hangers for minimum 3 hangers away from top and bottom elbows and from each take off at riser.
3. Guide vertical piping 2” and smaller at every floor. Guide 2-1/2” and larger at every other floor. Spring hangers (Type 6) and guides (Type VSG) are specified in Section 23 0550 - Vibration Isolation.

B. Ambient Bare Piping:
1. Unless otherwise indicated, maximum vertical support spacing for ambient bare steel and cast iron pipes shall be 15 ft.
2. Maximum vertical support spacing for other piping including copper tubing and plastic piping shall be 10 ft.
3. Install riser clamps and intermediate supports as required.
4. Rest riser clamps on floor or on pipe sleeve.

3.4 INSULATION PROTECTION SHIELDS

A. Install insulation protection shields at support points as specified under Insulated Pipe Supports.
1. Use one shield (bottom) for clevis hanger.
2. Use 2 shields (top and bottom) for roller hanger/support or strap/clamp support. Apply 2 metal straps to hold top and bottom shields onto insulation jacket.

3.5 INSULATION PROTECTION SADDLES

A. Install saddles at support points as specified under Insulated Pipe Supports. Tack weld saddle to pipe. Pack saddle cavity with insulation of same type as specified for piping system.

3.6 INSULATED PIPE SUPPORTS

A. Install insulated pipe support at each support point of insulated pipe. Provide insulation protection shields except where saddles are used.

B. Pipe Size 1-1/2” and Smaller:
1. Use insulation protection shields. Pipe insulation specified in Section 20 0700 - Mechanical Systems Insulation shall be continuous through support points.

C. Pipe Size 2” and Larger:
1. Use pre-insulated pipe supports. Refer to Part 2 for acceptable products.
2. In lieu of pre-insulated pipe supports, field-assembled insulated pipe supports may be used. If used, submit application details including materials, thickness, compression strength, load bearing surfaces, load calculations of support assembly and total pipe weight based on support spacing.
3. Field-assembled insulated pipe supports shall consist of weight bearing insulation inserts and insulation protection shields.
4. Insulation protection saddles may be used in lieu of assembled insulated pipe supports on roller hangers/supports for hot water pipes, low pressure steam and steam condensate pipes.

3.7 CONCRETE INSERTS

A. Concrete insert application, size, loading, and placement shall be reviewed and approved by Structural Engineer prior to installation.

B. Coordinate with General Contractor for placement of inserts before concrete pour. Minimize use of inserts and anchors after concrete pour.

3.8 CONTINUOUS INSERT CHANNELS

A. Mount continuous insert channels when used for pipe support on 8’-0” maximum centers and 2’-0” from corners.

3.9 BEAM CLAMPS

A. Provide locknut for hanging rod at clamp.

B. C-clamps are allowed for rod size 3/8” or smaller and only for static loading such as air piping, cold water piping, fire protection piping and, other similar piping and ductwork. C-clamps are not allowed for hot water piping and steam and steam condensate piping, except hot water runouts to terminal heating devices.

3.10 TRAPEZE SUPPORTS

A. Construct trapeze supports with struts, angles, or channels and hang them by inserts or welded beam attachments and rods.

B. Determine trapeze supports spacing by the smallest pipe on trapeze.

3.11 PIPE MOUNTING PEDESTALS

A. Use for all piping on roof. Install bottom of pedestal flat on roof deck, insulate exterior of pedestal, flash and counter flash.

3.12 EQUIPMENT RAILS

A. Use for all roof-mounted equipment, which is not curb mounted. Install bottom of equipment rail flat on roof deck. Insulate exterior of equipment rail.

B. Flashing will be by General Contractor. Provide counter flashing as specified and secure to wood nailer with stainless steel truss head screws.

3.13 CONCRETE ANCHORS

A. Anchor application, size, and placement shall be reviewed and approved by Structural Engineer prior to installation.

3.14 PIPE ROOF PENETRATION PROTECTIONS

A. Install at points where pipes are penetrating roof. Install as shown and according to manufacturer's installation instructions.

3.15 PIPE GUIDES

A. Install where shown on drawings.

B. For manufactured expansion devices, install minimum of 2 pipe guides at each side of manufactured pipe expansion device. Locate first guide no more than 4 pipe diameters from expansion device and second guide at 14 pipe diameters from first guide. Install intermediate guides in accordance with guide spacing data recommended by manufacturer or the following table, whichever is more stringent.

MAXIMUM DISTANCE BETWEEN INTERMEDIATE GUIDES (FT)

	Pipe Operating Pressure			
Pipe Size	0-50 psig	51-100 psig	101-150 psig	151-200 psig

(inches)				
3	21	19	17	16
4	35	29	25	22
6	57	44	37	32
8	66	52	45	40
10	91	69	58	51
12	107	79	66	58
14	115	85	71	62
16	127	94	78	68

C. If anchor is located within 4 pipe diameters from expansion joints, guides need not be installed on anchor side.

3.16 PIPE ANCHORS

A. Install anchors where shown on drawings or in conjunction with expansion joints, loops and swing joints as required to allow proper expansion and contraction of piping without damage to structure, equipment or piping.

B. Do not anchor piping to concrete block walls, wood, or partition walls.

End of Section

SECTION 20 05 53

MECHANICAL SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.1 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.2 SUBMITTALS

A. Product Data: For identification materials and devices

B. Valve Schedules: For each piping system

PART 2 - PRODUCTS

2.1 IDENTIFYING DEVICES

A. Marker System:
1. Manufacturers: Brady USA, Marking Services Inc. (MSI), Kolbi, or Seton
2. Manufacturer's standard, preprinted with color coding, lettering size and length of color field according to ASME A13.1.
3. Use pressure-sensitive type or "snap-on" type.
4. "Strap-on" type may be used for piping over 6” size including insulation.

B. Valve Tags:
1. Minimum 1-1/2” diameter 0.032” thick, polished brass or 316 stainless steel.

C. Laminated Plastic Nameplates:
1. Nameplates shall be approximately 1-1/2" x 4", 1/16”thick, and have 1/2” high lettering. Face of plastic nameplates shall be black with white letters.
2. Fasteners shall be self-tapping, stainless steel screws or contact type with permanent adhesive.

D. Underground Warning Tape:
1. Manufacturers: Brady USA, Marking Services Inc. (MSI), Kolbi, or Seton
2. Underground warning tape, 5.0 mil overall thickness, 2” width minimum, aluminum foil core where required to be detectable, bonded polyethylene jacket. Brady “Identoline” or equal.
3. Following services shall be provided with warning tape with colors and trace wire as indicated:
a. Natural Gas: Yellow with black letters, detectable
b. Fuel Oil: Yellow with black letters, detectable
c. Water Lines: Blue with black letters, [non] detectable
d. Sanitary Sewer: Green with black letters, [non] detectable
e. Storm Sewer: Green with black letters, [non] detectable

PART 3 - EXECUTION

3.1 GENERAL

A. After painting and/or covering is completed, identify equipment and piping as indicated. Locate identification as conspicuously as possible except where such would distract from finished area.

B. Where markers are used in high heat applications or exposed to harsh chemical or acid environments, specifically select marker materials for those applications.

3.2 PIPING SYSTEM IDENTIFICATION

A. Install pipe identification on each system. Place flow directional arrows at each pipe identification location.

B. Identify all piping not less than once every 25 ft, not less than once in each room, at each branch, adjacent to each access door or panel, at each valve and where exposed piping passes through walls and floors.

C. Identify piping with marker system.

1. For "strap-on" type, ensure marker is fitted snugly to pipe or pipe insulation surface with sufficient straps.

3.3 VALVE IDENTIFICATION

A. Identify valves with brass tags bearing system identification and valve sequence number in 1/2” black characters. Attach tag to valve body with brass jack chain and "S" hook for brass tag and SS jack chain or SS braided wires with swag sleeves and "S" hook for stainless steel tag. Non-metallic fasteners are not allowed.

B. Valve numbers shall be prefixed with corresponding piping system identification in 1/4” black letters.

C. Valve tags are not required at terminal devices unless valves are greater than 10 ft. from device or located in another room not visible from terminal unit.

D. Furnish typewritten valve schedule indicating valve number, fixtures, equipment or areas served by each numbered valve and incorporate in O&M Manuals.

E. Furnish typewritten framed chart under glass or clear plastic indicating fixtures, equipment or areas served by each numbered valve and mount same as directed by Architect.

3.4 EQUIPMENT IDENTIFICATION

A. Identify major equipment, including air handling units, fans, heat exchangers, air terminal devices, pumps, water heaters, tanks, compressors, etc.

B. Identify equipment by stenciling equipment number and service in 2” high letters.

C. Identify equipment with marker system.

D. Identify equipment with laminated plastic nameplates.

E. Identify control equipment and panels with laminated plastic nameplates.

F. Locate motor nameplates for easy reading. Relocate or provide new nameplates on motors if original nameplates are not located for easy reading.

3.5 ACCESS PANEL IDENTIFICATION

A. Furnish typewritten charts with identification and location of all access panels serving equipment and valves and incorporate in O&M Manuals.

3.6 SPRINKLER ZONE CONTROL VALVE IDENTIFICATION

A. Identify sprinkler zone control valves with laminated plastic nameplates. Nameplate shall include name of sprinkler zone served and description of area served.

3.7 UNDERGROUND WARNING TAPE

A. Install detectable warning tape 4” to 6” below grade to allow for accurate above surface detection.

B. Install non-detectable warning tape 6” to 12” below grade.

C. Repair and replace existing underground warning tape where disturbed by excavation.

End of Section

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SECTION 20 05 73

MECHANICAL SYSTEMS FIRESTOPPING

PART 1 - GENERAL

1.1 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 - General Requirements.

1.2 SCOPE

A. Work under this Section includes but is not limited to the following:
   1. Penetrations through fire-resistance-rated floor, roof, walls and partitions including openings containing pipes, ducts and other penetrating items.
   2. Penetrations through non-fire-resistance-rated floors where vertical service riser penetrates 3 or more floors.

1.3 SYSTEM PERFORMANCE REQUIREMENTS

A. Firestopping systems shall be UL Classified for the application and correspond to those indicated by reference to designations listed by UL Fire Resistance Directory.

B. Firestop materials and methods shall conform to requirements of Local Code Authority Having Jurisdiction.

1.4 SUBMITTALS

A. Manufacturer's specifications and technical data for each material including composition and limitations, documentation of UL Certification for firestop systems to be used and manufacturer's installation instructions.

B. Material safety data sheets provided with product delivered to job-site.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who has completed firestopping that is similar in material, design and extent as that indicated for Project and that has performed successfully.

B. A manufacturer's direct representative to be on-site during initial installation of firestop systems to train appropriate contractor personnel in proper selection and installation procedures.

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver products to project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product, type and UL Label where applicable.

B. Store materials to prevent deterioration or damage due to moisture, temperature changes, contaminants or other causes.

C. Handle in accordance with recommended procedures, precautions or remedies described in material safety data sheets as applicable.

1.7 PROJECT CONDITIONS

A. Do not install firestopping when ambient or substrate temperatures are outside limits permitted by firestopping manufacturer or when substrates are wet due to rain, frost, condensation or other causes.

B. Ventilate firestopping per manufacturers' instructions by natural means or, where this is inadequate, forced air circulation.

1.8 SEQUENCING AND SCHEDULING

A. Do not cover up those firestopping installations that will become concealed behind other construction until authorities having jurisdiction, if required, have examined each installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. 3M, Hilti, Tremco, Nelson Firestop Products, Specified Technologies, Inc, or Rectorseal Corp.

B. Pro-set firestop products may be used for specific applications, provided products meet requirements in this Section.

2.2 MATERIALS

A. Use only firestop products that have been UL 1479, ASTM E-814 Tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements and fire-rating involved for each separate instance.

B. Materials shall not contain flammable solvents.

2.3 MIXING

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

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for opening configurations, penetrating items and other conditions affecting performance of firestopping.

B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean out openings immediately prior to installing firestopping to comply with recommendations of firestopping manufacturer.

B. Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.

C. Comply with manufacturer's recommendations for temperature and humidity conditions before, during and after installation of firestopping.

3.3 INSTALLATION

A. Comply with "System Performance Requirements" Article in Part 1 and manufacturer's installation instructions and drawings.

B. Install forming/backing materials and other accessories of types required to support fill materials during application as required. After installing fill materials and materials have cured, remove forming materials and other accessories not indicated as permanent components of firestop systems.

C. Avoid multiple penetrations of common fire barrier opening. Seal each penetration in accordance with manufacturer's UL installation details. When multiple penetrations are unavoidable, seal openings with appropriate UL Classified firestopping systems.

3.4 IDENTIFICATION

A. Identify Through-Penetration Firestop Systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include the following information on labels:

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

3.5 CLEANING

A. Clean surfaces adjacent to sealed holes and joints to be free of excess firestop materials and soiling as Work progresses.

End of Section

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SECTION 20 07 00

MECHANICAL SYSTEMS INSULATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 05 29 - Mechanical Supporting Devices

B. Section 23 31 14 - Ductwork (Duct Lining)

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Provide insulating materials and accessories as required for mechanical systems as specified below.

B. Insulating products delivered to construction site shall be labeled with manufacturer's name and description of materials.

1.4 DEFINITIONS

A. Concealed areas, where indicated in this Section, shall apply to shafts, furred spaces and space above finished ceilings, inaccessible tunnels and crawl spaces. All other areas, including walk-through tunnels, shall be considered as exposed.

B. Unless otherwise indicated, unit of thermal conductivity is Btu·in/(h·ft^2·°F.

C. Interstitial spaces are considered as concealed areas.

1.5 SUBMITTALS

A. Shop Drawings for each piping system for all pipe sizes, each ductwork system, and all equipment including, but not limited to, the following:

1. Manufacturer's name
2. Schedule of insulating materials
3. Insulation material and thickness
4. Jacket
5. Adhesives
6. Fastening methods
7. Fitting materials
8. Intended use of each material
9. Manufacturer's data sheets indicating density, thermal characteristics, temperature ratings
10. Insulation installation details (manufacturer's installation instruction/details, Contractor's installation details, MICA plates where applicable)
11. All other appropriate data

1.6 DELIVERY, STORAGE AND HANDLING

A. Insulation material shall be delivered to project site in original, unbroken factory packaging labeled with product designation and thickness. Shipment of materials from manufacturer to installation location shall be in weather-tight transportation. Protect insulation materials from moisture and weather during storage and installation. Protect insulation material against long exposure to UV light from sun.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Owens Corning, Johns Manville, Knauf or CertainTeed similar to product indicated except where product of manufacturers not listed above is specifically identified for special type of insulation.

2.2 MATERIALS

A. Products used for or related to air conditioning and ventilating systems shall conform to NFPA 90A possessing flame spread rating of not over 25 and smoke developed rating no higher than 50.

B. Unless otherwise indicated, all products, material itself or on a composite basis, shall meet ASTM E-84, UL 723 or NFPA 255 and shall not exceed 25 flame spread and 50 smoke developed.

C. Pipe insulation which is not located in air plenum may have flame spread rating not over 25 and smoke developed rating no higher than 450 when tested in accordance with UL 723 and ASTM E84.

D. Outdoor insulation may have flame spread rating not over 75 and smoke developed rating not higher than 450.

E. Insulation applied on stainless steel shall meet requirements of ASTM C795 and NRC 1.36.

2.3 INSULATION

A. Insulation materials shall be fire retardant, moisture and mildew resistant, vermin proof, and suitable to receive jackets, adhesives and coatings as indicated.

B. Glass fiber insulation shall be of inert inorganic material, non-corrosive to mechanical surfaces.

C. Insulating cement shall be Quick-Cote by PK Insulation MFG Co. or Ryder GP, with dry density of no more than 38 lb/ft^3 thermal conductivity of 0.96 at 400°F mean temperature, and service temperature to 1200°F.

D. Filling and finishing cement shall be Super-Stik by PK Insulation MFG Co., or Ryder MW, with dry density of no more than 24 lb/ft^3, thermal conductivity of 0.74 at 500°F mean temperature, and service temperature to 1900°F.

E. Type A Insulation (Closed Cell Elastomeric Thermal Insulation):

1. Minimum nominal density of 6 lb/ft^3, thermal conductivity not more than 0.28 at 75°F mean temperature, maximum water vapor transmission of 0.08 perm-inch and suitable for temperatures from -70 to 220°F, Armacell Model AP/Armaflex, K-Flex USA, or Aeroflex Model Aerocel.

F. Type F Insulation (Flexible Glass Fiber):

1. Minimum density of 0.75 lb/ft^{3}with thermal conductivity of not more than 0.29 at 75°F mean temperature, and suitable for temperatures to 250°F. Owens Corning "All Service Duct Wrap", Johns Manville Microlite.

G. Type G Insulation (Cellular Glass):

1. 100% cellular glass cells with no organic material, noncombustible, 0.00 perm-inch permeability, 7.5 lb/ft^3 average density, compression strength 90 psi, thermal conductivity of not more than 0.31 at 50°F mean temperature and service temperature of 900°F. Pittsburgh Corning Foamglas or approved equal.

H. Type P Insulation (Expanded Polyisocyanurate):

1. Continuously molded rigid polyisocyanurate foam insulation meeting requirements of ASTM C-591, with thermal conductivity of not more than 0.19 at 75°F mean temperature, minimum nominal density of 2 lb/ft^3, minimum compressive strength of 24 psi, maximum water vapor transmission of 4.0 perm-inch, maximum water absorption of 2% by volume, and suitable for temperature of plus 300°F down to –297°F. Insulation shall have factory-applied jacket with SSL. Trymer 2000 XP by ITW or approved equal.

I. Type R Insulation (Rigid Glass Fiber):

1. Minimum nominal density of 3 lb/ft^3 with thermal conductivity of not more than 0.23 at 75°F mean temperature. Minimum compressive strength at 10% deformation shall be 25 lb/ft^2.
2. Pipe insulation shall be suitable for temperatures to 850°F, Johns Manville Micro-Lok 850, Owens Corning Fiberglas ASJ/SSL-II.
3. Duct and equipment insulation shall be suitable for temperatures to 450°F, Johns Manville Spin-Glas Type 814, Owens Corning Type 703.
4. Pipe and tank wrap faced with specified jacket may be used for equipment and round ducts insulation, provided that it meets all insulation characteristics requirements stated above and maintains same R-value as specified.

J. Type RR Insulation (Rigid Glass Fiber):

1. Minimum nominal density of 6 lb/ft^3 with thermal conductivity of not more than 0.22 at 75°F mean temperature. Insulation shall be suitable for temperatures to 450°F. Minimum compressive strength at 10% deformation shall be 200 lb/ft^2, Johns Manville Spin-Glas Type 817 or Owens Corning 705.
2. TUFF-R Polyisocyanurate Insulation by Celotex may be used for Type RR insulation specified for exterior rectangular ductwork, provided minimum thickness is 3/4” and R-value is not less than R-value specified.
3. Pipe and tank wrap faced with specified jacket may be used for equipment and round duct insulation, provided that it meets all insulation characteristics requirements stated above and maintains same R-value as specified.

2.4 JACKETS

A. Jacket puncture resistances shall be based on ASTM D-781 test methods. Vapor barrier permeance ratings shall be based on ASTM E-96 Procedure A.

B. Type A-1 Jacket (Protective Insulation Shield):

1. Factory fabricated 0.0.016”, ASTM B209, Type 3003 or 1100, stucco embossed aluminum jacket with integrally bonded polykraft moisture barrier, complete with integral longitudinal Pittsburgh Z-Lock seam.
2. Fitting covers shall be factory fabricated from not lighter than 0.024” thick, Type 3003 or 1100 aluminum.
3. Jacketing system shall be equal to Childers Lock-On.

C. Type D-1 Jacket:

1. Heavy-duty, fire retardant material with glass fiber reinforcing. Jackets shall have neat, white Kraft finish suitable for painting, with beach puncture resistance of 50 units minimum. Vapor barrier shall be adhered to inner surface of jacket. Permeance shall not exceed 0.02 perm. Owens Corning "ASJ", Johns Manville "AP".

D. Type D-2 Jacket:

1. Glass fiber reinforced foil Kraft laminate with permeance not exceeding 0.02 perm and beach puncture resistance 25 units minimum. Owens Corning "FRK", Johns Manville "FSK".

E. Type D-3 Jacket:

1. Self-adhering, multiple laminated waterproofing material with reflective aluminum foil, high density polymer films and minimum 40 mil rubberized asphalt waterproofing compound, similar to Peel and Seal or Flex Clad 400 by MFM Building Products Corp. or Alumaguard 60 by Polyguard.
2. Venture Clad 1577 CW may be used.
   a. Jackets shall be minimum 5 ply laminated, weather proofing material with acrylic adhesive capable of installation with no additional mechanical attachments, 0.00 water vapor permeance rating per ASTM E-96, mold inhibitors incorporated and UV stable.
   b. Jackets shall have [aluminum][white][embossed aluminum][embossed white][tedlar] finish.
3. Products shall carry minimum 10 yr manufacturer's warranty.

F. Type E-1 Jacket:

1. Glass fiber reinforcing fabric imbedded in weather barrier mastic as per manufacturer's recommended procedure for 2 coat application.

G. Type P-1 Jackets:

1. Heavy-duty, fire retardant material with glass fiber reinforcing and self-sealing lap. Jacket shall have neat, white Kraft finish suitable for painting, with beach puncture resistance of 50 units minimum. Vapor barrier shall be adhered to inner surface of jacket. Permeance shall not exceed 10.02 perm. Owens Corning "ASJ-SSL", Johns Manville flame-safe "AP-T".

H. Type S-2 Jacket:

1. Saran Vapor Retarder Film with self-sealing lap (SSL), ASTM C-755 and C-1136, 6 mil thickness. Permeance shall not exceed 0.01 perms, equal to Dow Saran 560.
2. Elbows, fittings, valves and butt joints shall be wrapped with 3 layers of Dow Saran 520 Vapor Retarder tape.
3. Provide PVC jacket (Type V-1) over Saran tapes for exposed elbows, fittings and valves.

2.5 ADHESIVES, MASTIC, COATINGS, SEALANTS, AND REINFORCING MATERIALS

A. Products shall be compatible with surfaces and materials on which they are applied, and shall be suitable for use at operating temperatures of systems to which they are applied.

B. Products shall be fire retardant, moisture resistant and mildew resistant and vermin proof.

C. Adhesives, mastic, sealants, and protective finishes shall be as recommended by insulation manufacturer for specified application.

D. Glass fiber fabric reinforcing shall be 10 x 10 or 20 x 10 mesh.

E. Wire mesh reinforcing shall be 22 ga 1” galvanized.

F. Insulation cement shall be ANSI/ASTM C195, hydraulic setting mineral wool.

G. Finishing cement shall be ASTM C449.

H. Butt joint and longitudinal joint adhesive for Type A insulation shall be Armstrong 520, Rubatex 373 or Manville 57.

I. Weather-resistant protective finish for Type A insulation shall be equal to Armstrong WB Armaflex finish.

2.6 METAL BANDS AND WIRES

A. Aluminum bands shall be 0.5" x 0.020” up to 48” diameter and 0.75" x 0.020” over 48” diameter.

B. Stainless steel bands shall be 0.5" x 0.015” or 0.75" x 0.015”.

C. Stainless steel wires shall be 16 ga.

2.7 REMOVABLE INSULATING BLANKETS

A. Custom designed removable, reusable, flexible, blanket thermal insulation system.

B. Acceptable Manufacturers: Thermal Energy Products, Inc., Advanced Thermal Corp., Temptec and Remco Technology, Inc

C. Removable insulation system shall be custom designed for each individual item to provide close contour fit. Overlapping seams and gaps are not acceptable.

D. Removable insulation shall be designed to overlap adjoining pipe insulation by 50 mm.

E. Insulation: Minimum 2" thick, 2.4 lb/ft^3 density, 1000°F continuous service temperature thermal insulating wool; Owens Corning Fiberglass or equal.

F. Interior and Exterior Fabric: Minimum weight 17.5 oz/sq yd silicone rubber coated fiberglass cloth.

G. Identification/Tagging: Label each removable insulation device with plastic or 304 stainless steel tag with raised letters. Tag as directed by Laboratory.

2.8 ACOUSTICAL BARRIER MATERIALS

A. Acoustical barrier material shall be similar to Kinetics Model KNM-100ALQ. Barrier material shall have acoustic ratings of STC-26, 1.0 lb/ft^{2}nominal density, flame spread index less than 25, smoke developed index less than 50, and minimum continuous operating range from 40°F to 220°F.

B. Minimum sound transmission loss at each octave band shall be as follows:

Sound Transmission Loss (dB)					
Octave Band Center Frequency (Hz)					
125	250	500	1000	2000	4000
13	16	21	26	33	38

PART 3 - EXECUTION

3.1 APPLICATION

A. Provide insulation and jackets as indicated in the following schedule. The schedule applies to both exposed and concealed applications unless noted otherwise:

Piping System

Service	Jacket Type	Insulation Type	Insulation Thickness According to Pipe Size				
			3/4" and less				3/4" and less
Heating Hot Water (105-140°F)	P-1	R	1"	Heating Hot Water (105-140°F)	P-1	R	1"
Heating Hot Water (141-200°F)	P-1	R	1-1/2"	1-1/2"	1-1/2"	1-1/2"	1-1/2"
Heating Hot Water (201-250°F)	P-1	R	1-1/2"	1-1/2"	2"	2"	3-1/2"
Chilled Water	S-2	P	1"	1"	1"	1"	1-1/2"
Refrigerant Suction Lines and Hot Gas By-pass Line if Used	-	A	1"	1-1/2"	1-1/2"	1-1/2"	2"
Provide protective coating paint for exterior piping as recommended by Insulation Manufacturer.							
Cooling Coil Condensate Drain	P-1	R	1"	1"	1"	1"	1"
Type A 3/4" thick insulation may be used.							
Low Pressure Steam and Condensate	P-1	R	40 mm	40 mm	50 mm	50 mm	90 mm
Domestic (Potable) Cold Water	P-1	R	1"	1"	1"	1"	1"
(Type A Insulation is an option	--	A	3/4"	3/4"	3/4"	3/4"	3/4"
Domestic (Potable) Hot Water and Hot Water Return (105-140°F)	P-1	R	1"	1"	1-1/2"	1-1/2"	1-1/2"
	--	A	1"	1"	1-1/2"	NA	NA
(Type A insulation is an option.)							
Tempered Water	P-1	R	1"	1"	1-1/2"	1-1/2"	1-1/2"
Laboratory and Nonpotable Cold Water	P-1	R	1"	1"	1-1/2"	1-1/2"	1-1/2"
(Type A insulation is an option.)	--	3/4"	3/4"	3/4"	3/4"	3/4"	3/4"
Laboratory and Nonpotable Hot Water and Hot Water Return (105-140°F)	P-1	R	1"	1"	1-1/2"	1-1/2"	1-1/2"
	--	A	1"	1"	1-1/2"	NA	NA
Storm and overflow	P-1	R	NA	1"	1"	1"	1"

Piping System

Service	Jacket Type	Insulation Type	Insulation Thickness According to Pipe Size				
			3/4" and less				3/4" and less
piping including roof drain body.	--	A	NA	3/4"	3/4"	3/4"	NA
		(Type A insulation is an option.)					
Clearwater Waste	P-1	R	1"	1"	1"	1"	1"
	--	A	3/4"	3/4"	3/4"	3/4"	NA
		(Type A insulation is an option.)					
Vent Piping (10’ to Vent through Roof)	P-1	R	1"	1"	1"	1"	1"
	--	A	3/4"	3/4"	3/4"	3/4"	NA
		(Type A insulation is an option.)					

Insulated Exterior Piping	Unless otherwise indicated, provide protective insulation shield (Type A-1 jacket) in addition to pipe insulation and jacket specified in this schedule.
Insulated Piping in Air Handling Unit Housing	Provide V-1 jacket in addition to insulation jacket specified in this schedule.
Insulated Piping Subject to Abuse as Indicated on Drawings	Provide Type H insulation with E-1 jacket in lieu of specified insulation/jacket with same insulation thickness.

Ductwork/Equipment System

Service	Jacket Type	Insulation Type	Insulation Thickness
OA Ducts Exposed	D-1 or D-2	R	2”
OA Ducts Concealed	D-2	R	2”
Supply Ducts Exposed	D-1	R	1-1/2”
Supply Ducts Concealed	D-2	F	2”
Exhaust or Relief Ducts from Control or BD Damper to Outside Wall or Roof	D-1	R	1-1/2”
Return and Relief Ducts in Equipment Rooms	D-1	R	1-1/2”
Exhaust Ducts Downstream from Heat Recovery Units - Exposed	D-1	R	1”
Exhaust Ducts Downstream from Heat Recovery Units - Concealed	D-2	F	2”
Fume Exhaust Ducts Exterior up to Exhaust Fan Inlet.	D-2 & D-3	RR	2”
Air Separators & Water Filters (Hot Water)	E-1	R	2”
Heat Exchangers (Plate and Frame Type)	---	A	1”
Chilled Water Expansion Tanks	---	A	3/4”
Humidifier Separator	E-1	R	2”
Raw Water Make Up Tanks	E-1	R	1”
Water Softener Mineral Tanks	E-1	R	1”

Ductwork/Equipment System

Service	Jacket Type	Insulation Type	Insulation Thickness
	---	A	1”

B. Type F insulation with Type D-2 jacket may be used in lieu of Type R insulation with Type D-1 jacket for ductwork located 6 ft. or higher above floor in mechanical equipment rooms. Horizontal ducts that are not completely 6 ft above floor shall be insulated with Type R insulation as specified for its entirety.

3.2 INSTALLATION - GENERAL

A. All insulation installation methods shall be performed in accordance with the latest edition of National Commercial and Industrial Insulation Standards published by MICA (Midwest Insulation Contractors Association) and manufacturer's installation instructions, except as modified in this Section of specifications.

B. Install products with good workmanship, with smooth and even surfaces. Use full-length factory-furnished material where possible. Do not use scrap pieces.

C. Apply insulation only on clean, dry surfaces, after all rust and scale have been removed and testing of systems has been completed. Do not insulate any section of system that must be pressure tested until after it has been successfully tested. Any removal and reinstallation to correct system defects prior to end of guarantee period shall be accomplished at no expense to Laboratory.

D. Install insulating materials with necessary joints and terminations, to permit easy access and removal of equipment sections where inspection, service or repair is required, and to allow for expansion.

E. Where possible longitudinal joints in jackets shall face toward wall or ceiling.

F. Apply insulation to each pipe or duct individually. Common insulation applied to adjacent pipes or ducts will not be accepted.

G. Unless otherwise indicated, pipe and duct insulation shall be continuous through walls and floors.

H. Where multiple layers of insulation are used, stagger and secure each layer with metal bands.

I. Where penetrations occur through fire-rated walls, partitions, or floors, provide fire seal as specified in Section 20 0000 - General Mechanical Requirements and Section 20 0573 - Mechanical Systems Firestopping.

J. Insulate water piping within casework up to penetration of casework pipe chase at fixture stop. Insulate water piping within walls up to pipe penetration through the wall at fixture stop when serving wall-mounted fixtures. Termination of insulation shall be in neat and workman like manner with insulation jacket cap.

K. Insulate the following systems for complete vapor barrier protection:
   1. Chilled Water
   2. Refrigerant
   3. Cooling coil condensate drain
   4. Storm
   5. Clearwater Waste
   6. Cold Water
   7. Raw water make-up
   8. All insulated ductwork
   9. All equipment with surface temperature below 65°F

L. Apply Type A insulation for insulation and jackets requiring vapor barrier protection where specified insulations are cut for mounting sensors, control devices, parts of valves, devices or components which extend out from specified insulation to prevent condensation.

3.3 GLASS FIBER FABRIC COVERING (TYPE E-1 JACKET)

A. Glass fiber fabric shall be fitted without wrinkles.

B. Glass fiber fabric shall be sized immediately upon application with lagging adhesive and shall be capable of drying within 6 h.

C. Apply adhesive and coating in accordance with manufacturer's recommendations.

D. All seams shall overlap not less than 2”.

3.4 PIPING, VALVE AND FITTING INSULATION

A. Apply insulation to pipe, unions, flanges, fittings, valves and piping specialties with butt joints and longitudinal seams closed tightly. Valve insulation shall cover entire valve body including bonnets and packing nuts.

B. Laps on factory-applied jackets shall be 2” minimum width firmly cemented with lap adhesive, or shall be pressure sealing type lap.

C. Cover joints with factory furnished tape 3” minimum width to match jacket. Cement firmly with lap adhesive.

D. Secure insulation, except insulation covered with vinyl jackets, additionally with staples.

E. Where staples are used, they shall be on 6” maximum centers. When used for systems requiring vapor barrier, cover lap and staples with finish coat of lagging adhesive.

F. Built-up insulation for fittings and valves shall be made with sectional insulation, wrapped firmly to thickness of adjoining pipe insulation, and bound with jute twine, or built up with insulating cement, and finished to smooth hard surface, and covered with minimum of 0. 9 oz per sq yd rewettable glass cloth similar to Clairmont Diplag 60.

G. For valves and fittings requiring vapor barrier, apply 2 coats of vapor barrier mastic with glass fiber reinforcing fabric after application of insulating cement. For valves and fittings not requiring vapor barrier, apply 2 coats of weatherproof mastic with glass fiber reinforcing fabric after application of insulating cement. Apply coating in accordance with manufacturer's recommended procedure.

H. For finishing of insulated pipe fittings and valves where surface temperature of insulation is not higher than 125°F, one piece PVC fitting covers, minimum thickness of 20 mil, may be used. Fitting covers located in mechanical rooms within 8 ft above floor shall be 30 mil thickness. Johns Manville Zeston 2000 PVC, PROTO Fitting Covers, or similar by other manufacturers listed. Where fitting and valve insulation requires vapor barrier, seal joints of PVC covers with vapor barrier adhesives. Insulation type, R-value and density of insulation used at fittings shall match those of adjacent piping. Install insulation at pipe fittings and valves completely prior to applying PVC covers.

I. Where terminations of pipe insulation are required, insulation shall have tapered ends, built up and finished as specified for fittings.

J. For pipes 1-1/2” and smaller, install specified pipe insulation and jacket continuous through hanger or support locations. Install insulation protection shields to protect insulation from compressing.

K. For pipes 2” and larger, where manufactured pre-insulated pipe supports are used at hanger or support locations, extend insulation to insulated pipe supports. Where vapor barrier is required, this Contractor shall be responsible for continuity of vapor barrier at insulated pipe supports. Use 3” wide vapor barrier tape on hot and cold systems at pipe supports.

L. For pre-insulated pipe supports and insulation protection shields, refer to Section 20 0529 - Mechanical Supporting Devices.

M. For Contractor-fabricated anchors, secure insulation directly to pipe surface and extend insulation up anchor for distance of 4 times insulation thickness. For pre-insulated anchors, cover entire surface of anchors with Type A insulation. Where applicable, take special care to assure vapor seal at anchor.

N. Where mechanical grooved pipe connections are used in piping system, insulate couplings as specified for pipe.

O. Piping, fittings and valves not to be insulated:
   1. Heating hot water piping inside fin tube radiation enclosures
   2. Control valves and balancing valves for heating terminal devices
   3. Valves furnished with removable insulation/jacket
   4. Steam system traps

3.5 EQUIPMENT INSULATION

A. Apply insulation to equipment shells with bonding adhesive and wire in place. Fill joints and seams with insulating cement and cover insulated surfaces with wire reinforcing mesh. Apply additional coat of insulating cement, cover with glass fabric as specified herein, and finish to smooth hard surface.

B. For equipment shells requiring vapor barrier, apply 2 coats of vapor barrier mastic with glass fiber reinforcing fabric after application of insulating cement. For equipment shells not requiring vapor barrier, apply 2 coats of weatherproof mastic with glass fiber reinforcing fabric after application of insulating cement. Apply coating in accordance with manufacturer's recommended procedure.

C. For equipment requiring Type H, Type M or Type C insulation such as breechings, stacks, exhaust pipes and mufflers, apply insulation to equipment and secure with stainless steel bands with tightly butted joints as recommended by manufacturer. Where multiple layers of insulation are required, stagger and secure each layer with stainless steel bands.

D. Install removable insulating boxes where access is required for cleaning, repair and inspection, including pump heads and strainers. Construct removable insulating boxes with split metal enclosures using minimum 24 ga galvanized sheet metal lined with Type A insulation adhered to inside of box with 520 adhesive. Do not apply bonding adhesive to equipment surface. Finish interior surface of insulating box to allow removal without damage. Provide fasteners, supports and membranes as required.

E. Provide removable insulating blankets on expansion joints.

F. Do not insulate over equipment nameplates or ASME stamps. Bevel and seal insulation at these locations.

G. Water chiller insulation shall include insulation of evaporator shell, water boxes and other miscellaneous piping and/or equipment as directed by equipment supplier. Provide removable insulating boxes at chiller water boxes. Verify that chillers are fully charged with refrigerant before insulating.

H. Equipment not to be insulated:
   1. Equipment furnished with factory insulation.

3.6 DUCTWORK AND COMPONENTS

A. Apply duct insulation evenly over duct surface. Unless otherwise indicated, insulation and jacket shall run continuously between duct and duct supports. Maintain insulation thickness specified over duct reinforcing members.

B. For support points of rectangular or oval ducts supported by trapeze hangers, place weight-supporting insulation at bottom of duct over trapeze. Weight supporting insulation inserts shall be minimum 6” long with same thickness as insulation specified and shall be similar to HAMFAB H-block by ICA Inc. Follow manufacturer's recommendation for quantity of inserts.

C. For support points of round ducts smaller than 16” diameter, weight-supporting insulation is not required for either rigid or flexible glass fiber insulation.

D. For support points of round ducts 16” diameter and larger, place weight-supporting insulation between duct and strap or trapeze. Weight-supporting insulation shall be minimum 6” long with same thickness as insulation specified and shall be similar to HAMFAB H-block by ICA Inc.

E. Flexible glass fiber insulation may be installed outside of support for round ducts 24” diameter or smaller, provided that vapor barrier integrity is maintained at rod penetration.

F. Secure flexible glass fiber insulation (Type F) to underside of horizontal rectangular or oval ductwork 24” in width or greater and on vertical sides of horizontal and vertical ductwork with weld pin or mechanical fasteners not over 18” on center and within 3” of butt joint or edge.

G. Secure rigid glass fiber insulation (Type R or Type M) to all sides of horizontal and vertical rectangular or oval ductwork with weld pin or mechanical fasteners. Install pins or fasteners as required to secure, but not less than 12” on center for underside and sides of ducts and 24” on center for top of ducts, and within 3” of butt joint or edge.

H. Clip pins fastened to ductwork with adhesives are not allowed. Where weld pin fasteners are used, install them without damage to interior galvanized surface. Clip pins neatly back to each fastener.

I. Where insulation is required for ductwork, provide insulation over entire ductwork system, including system components such as filters, mixing air chambers, sound attenuators, air measuring stations, reheat coils, etc. For fire dampers, smoke dampers and combination F/S dampers in ductwork requiring insulation, install insulation and jacket to wall and apply vapor barrier sealant to prevent condensation.

J. Provide insulation over supply air diffusers, grilles and unlined boots after termination point of flexible ducts or rigid duct insulation to prevent from sweating.

K. Where vapor barrier jackets are specified, pins shall be jacketed over with matching material. Where staples are used for systems requiring vapor barrier, cover lap and staples with finish coat of lagging adhesive.

L. Insulation without factory jacket shall be cut and mitered to suit surface. Build up voids, seams and joints with insulating cement, cover with glass fabric as specified herein and finish to smooth surface.

M. For other than factory-applied vapor barrier jackets, apply 2 coats of vapor barrier mastic with glass fiber reinforcing fabric, after application of insulating cement. For surfaces not requiring vapor barrier jackets, apply 2 coats of weatherproof mastic with glass fiber reinforcing fabric after application of insulation cement. Apply coating in accordance with manufacturer's recommended procedure.

N. D-1 jackets:

1. Butt together joints and seams firmly, cover with glass fiber fabric 4” minimum width and finish with 2 coats of vapor barrier mastic.

O. D-2 jackets:
   1. Butt together joints and seams firmly and cover with 3” wide FSK tape.

P. D-3 jackets:
   1. Install jacket in strict accordance with manufacturer's installation requirements.
   2. For rectangular ducts, overlap bottom half jacket and top half jacket at each side of duct at least 4” (bottom inside top outside at overlap).
   3. For round ducts, wrap duct insulation continuously with spiral shaped overlapping. Overlap at least 4”.
   4. Use welded stickpins for Type D-3 jacketing wider than 24”in width alongside and bottom surfaces of ducts. Retainers of stick pins shall be covered with Type D-3 patch, minimum 100 mm square, once retainer cup is in place on stick pin.

Q. Kitchen Exhaust Ducts:
   1. Insulate kitchen exhaust ducts except those exposed in kitchen. Impale insulation over weld pins on 12" centers longitudinally and 9" centers in transverse direction. Fasten with steel speed washers 0.019" x 2-1/2" x 2-1/2". Butt insulation edges tightly together and seal joints with 3" tape adhered and stapled with flare type staples on 4" centers.

R. Acoustical Barrier Materials:
   1. Provide 2” Type R insulation with Type D-1 jacket as inner layer. Over insulation install acoustical barrier materials as outer layer in accordance with manufacturer’s installation instruction.
   2. For ductwork specified with Type F insulation, replace it with insulation specified above.
   3. Refer to plans for ductwork requiring acoustical barrier materials.

S. Ductwork not to be insulated:
   1. Internally lined ductwork
   2. Ductwork components with factory installed insulation
   3. Exposed supply and return ductwork in shops and air conditioned spaces

3.7 PROTECTIVE INSULATION SHIELD (A-1 JACKET) FOR PIPE JACKETS EXTERIOR TO BUILDING

A. Unless otherwise indicated, install shields (A-1 jacket) around insulated pipe and fittings exterior to building. Seal water and vapor tight at terminations.

B. Longitudinal overlap shall be at least 50 mm wide with vapor barrier sealant.

C. Secure jacketing with 3/4" wide 0.015" stainless steel or 3/4" wide 0.020" aluminum bands and wing seals on maximum 18" centers.

3.8 TYPE G INSULATION (CELLULAR GLASS)

A. Install cellular glass insulation system in strict accordance with manufacturer's installation instructions.

B. Chilled Water Piping (Interior):
   1. Butter joints of insulation with Pittseal 727 or 444N Sealant. Apply insulation to pipe and fittings with joints tightly fitted and sealed full depth with joint sealant. Secure each length of insulation with 1” wide filament tape and stainless steel wire over tape. Apply insulation with joints fitted to eliminate voids. Eliminate voids by refitting or replacing insulation. Do not fill voids with joint sealer.
   2. Finish with specified jacket, joints and laps sealed with fire rated adhesive. Finish elbows and fittings with white PC-79 polyester fabric coated with Pittcote 404.

C. Steam and Steam Condensate Piping (with Type A-1 jackets):

1. Apply insulation to piping with all joints dry and tightly fitted without voids. Do not use glue on joints.
2. Secure insulation to piping with 1” wide, high tensile strength, fiber reinforced strapping tape similar to Scotch Brand Filament Tape and stainless steel wire over tape. Apply tape on equal spacing such that there are 2 rounds of tape per insulation section. Overlap tape minimum 50%.
3. Apply aluminum jackets over insulation.
   a. Seal water and vapor tight at terminations.
   b. Longitudinal overlap shall be at least 2" wide with vapor barrier sealant.
   c. Secure jacketing with 3/4" wide 0.015" stainless steel or 3/4" wide 0.020" aluminum bands and wing seals on maximum 18" centers. Provide minimum of 2 bands per section.

D. Steam and Steam Condensate Piping (Underground Direct Buried)
   1. Install insulation and jackets in accordance with Pittsburgh Corning Bulletin FI-213, Foamglas Insulation Systems for Underground Direct Burial Applications, and other appropriate Pittsburgh Corning product data sheets.

End of Section

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SECTION 21 00 00

GENERAL FIRE SUPPRESSION REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Specification requirements defined in Division 20 of this specification apply to, and are in addition to the work associated with equipment, systems, materials, and installation requirements specified in Division 21. Contractor shall provide the requirements specified in Division 20 to obtain complete systems, tested, adjusted, and ready for operation.

1.2 RELATED WORK

A. Section 20 00 00 - General Mechanical Requirements

B. Section 20 05 20 - Excavation and Backfill

C. Section 20 05 29 - Mechanical Supporting Devices

D. Section 20 05 53 - Mechanical Systems Identification

E. Section 20 05 73 - Mechanical Systems Firestopping

F. Section 20 07 00 - Mechanical Systems Insulation

PART 2 - PRODUCTS

2.1 NOT APPLICABLE TO THIS SECTION.

PART 3 - EXECUTION

3.1 NOT APPLICABLE TO THIS SECTION.

End of Section

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SECTION 21 13 14

AUTOMATIC FIRE SPRINKLER SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies materials, methods, and equipment to be used for automatic sprinkler system standpipe system and related fire protection piping to 5 ft outside building, except for the Storz Fire Department Connection.

B. Research indicates there is no documentation or indication that microbiologically influenced corrosion (MIC) exists in the area of the project.

C. NFPA 13's seismic requirements are not part of this project.

D. As shown on drawings, system(s) shall consist of:
   1. 4 automatic fire sprinkler zone(s) which consist of:
      a. 2 wet sprinkler zone(s)
      b. 1 dry sprinkler zone(s)
      c. 1 preaction sprinkler zone(s)

E. Each wet pipe zone shall begin with:
   1. Indicating-type floor control valve. Valve shall be unsupervised. The Laboratory shall provide lock and chain.
   2. Pressure gauge
   3. Water flow switch
   4. Inspector's test and drain assembly

F. Engineer of Record:
   1. Contractor shall be Engineer of Record. Contractor shall produce signed and sealed installation drawings, which are also referred to as shop drawings in this Section, based on design criteria listed in this Section and drawings furnished by Engineer. Contract drawings show zone and main piping layouts of fire protection systems as it relates to architecture, structure, and mechanical/electrical systems.

1.2 RELATED WORK

A. Section 20 00 00 – General Mechanical Requirements

B. Section 20 05 20 – Excavation and Backfill

C. Section 20 05 53 – Mechanical Systems Identification

D. Section 20 05 73 – Mechanical Systems Firestopping

E. Section 21 00 00 – General Fire Suppression Requirements

F. Section 26 05 93 – Electrical Systems Firestopping

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.4 QUALITY ASSURANCE

A. Codes and Standards:
   1. This installation shall conform to the most current editions of following codes and standards:
      a. NFPA 13, Installation of Sprinkler Systems.
      b. NFPA 14, Installation of Standpipe and Hose Systems.
      c. NFPA 24, Installation of Private Fire Mains and their Appurtenances
      d. NFPA 30, Flammable and Combustible Liquids Code
      e. NFPA 45, Fire Protection for Laboratories Using Chemicals
      f. NFPA 72, National Fire Alarm and Signaling Code
      g. NFPA 101, Life Safety Code
      h. International Building Code (IBC)
      i. International Fire Code (IFC)
      j. Local and State Building, Mechanical, and Fire Codes
      k. Underwriters Laboratories (UL) Fire Protection Equipment Directory

B. Contractor Installation Program:
   1. Provide licensed persons employed by sprinkler contractor to perform planning, calculations, layout, installation, and testing of fire protection systems. The following are acceptable:
      a. Certified sprinkler designer
      b. National Institute for Certification of Engineering Technologies, (NICET) Level IV
      c. Licensed Professional Engineer
   2. Provide journeyman sprinkler fitter(s) for installation and supervision.
   3. Contractor shall be licensed in the State of Illinois for installation of fire protection systems.
   4. Contractor shall submit pre-qualification evidence of at least 3 projects of comparable size successfully completed with their Bid.
   5. Distortion or misrepresentation of qualification evidence may result in contract cessation.

C. Electrical Coordination
   1. All relays, wire, conduit, pushbuttons, pilot lights, and other devices required for power side or the control of electrical equipment shall be furnished by Division 26 and Division 28 contractors, except as specifically noted elsewhere in this specification.
   2. Should any change in electrical equipment size, horsepower rating or means of control be made to any motor or other electrical equipment after contracts are awarded, sprinkler contractor is to immediately notify Division 26 and Division 28 contractors of this change and pay any costs due to this change.
   3. Division 26 contractors shall provide all power wiring and sprinkler contractor shall be responsible for providing all control wiring and its conduit. Control wiring shall conform to Division 26 and 28 requirements for control wiring.
   4. Sprinkler contractor shall provide exterior waterflow alarm and coordinate installation with Division 26 and Division 28 contractors.
   5. Furnish wiring diagrams to Division 26 and Division 28 contractors for equipment and devices furnished by sprinkler contractor which have been indicated to be wired by Division 26 and Division 28 contractors.

1.5 SUBMITTALS

A. Shop Drawings on Items Specified:
   1. Pipe, Fittings, and Joints
   2. Valves
   3. Flow Switches
   4. Exterior Weatherproof Waterflow Alarm
   5. Sprinkler Heads
   6. Sprinkler Head Cabinet
   7. Preaction Valve and Accessories
   8. Dry Pipe Valve and Accessories
   9. Hanger Assemblies
   10. Pressure Gauges
   11. Fire Department Connection (FDC)
   12. Double Check Detector Assembly (DCDA)
   13. Fire Valve Cabinets (FVC)
   14. Fire Department Valves (FDV)
   15. Hydraulic Calculations
   16. Drawings

B. Submit Material Safety Data Sheet (MSDS) for corrosion inhibitive paint.

C. Include items listed in product section and additional items required to provide complete installation.

D. Indicate by red marking or arrow, items that are to be provided, where more than 1 item appears on manufacturer's catalog sheet.

E. Submit stamped and sealed drawings, and product data sheets, and hydraulic calculations to Engineer and Laboratory's insurance representative prior to installation or fabrication of system components.

F. Submit stamped and sealed drawings, product data sheets, and hydraulic calculations to local Fire Department prior to installation or fabrication of system components.

G. Include copy of Fire Department plan review letter in submission to Engineer.

H. Prior to installation or fabrication of system components, submit layout drawings and equipment submittals to Engineer of Record.

I. After review of layout drawings by Engineer of Record, submit drawings and calculations to Local Authority Having Jurisdiction.

J. Review of submittals does not relieve Contractor from coordinating installation of work with other trades, or from compliance with Codes and Standards.

K. At completion of acceptance tests:
   1. Send copy of test log to Engineer
   2. Send copy of Contractor’s Material and Test Certificates to:
      a. Engineer
      b. Laboratory
      c. Authority Having Jurisdiction

3. Provide Laboratory with following:
   a. Manufacturer's literature and instructions describing operation and maintenance of equipment and devices installed.
   b. Typewritten chart with identification and location of all access panels serving equipment and valves. Incorporate into Operation & Maintenance (O&M) manual.
   c. Typewritten valve schedule indicating valve number, fixture/equipment or areas served by each numbered valve. Incorporate into O&M manual.
   d. Refer to Section 20 0000 General Mechanical Requirements for additional O&M manual requirements.
   e. Current copy of NFPA 25, Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials and Equipment:
   1. Materials and equipment in system shall be new and current products of manufacturer regularly engaged in production of such materials and equipment.
   2. Where 2 or more pieces of equipment are required to perform interrelated functions, they shall be products of same manufacturer.
   3. Clean and cap pipe after fabrication and prior to placing pipe in building.
   4. Mark pipe with tags that can be removed during installation so no permanent markings remain on unpainted pipe located in exposed areas.
   5. Couplings shall be tees with capped outlets.

B. Approval Guides:
   1. Unless otherwise shown, products shall be UL Listed in the latest publication of the UL Fire Protection Equipment Directory for service intended.

2.2 PIPE

A. Below Ground:
   1. Pipe: Ductile iron, Class 52, American Water Works Association (AWWA) C151, 150 psi working pressure, with standard cement mortar lining, AWWA C104, American National Standards Institute (ANSI) A21.4
   2. Fittings: Ductile iron or grey iron, mechanical joint, cement mortar lined, Class 250, AWWA C110
   3. Encasement: Polyethylene encasement, 8 mil thick, AWWA C105

B. Above Ground:
   1. Carbon Steel, 2” and smaller:
      a. Pipe: Carbon steel pipe, Schedule 40, American Society for Testing of Materials (ASTM) A795, A53, or A135
      b. Fittings:
         1). Malleable iron, threaded, Class 125, 175 psi Cold Water Pressure (CWP) rating, ANSI B16.3
         2). Cast iron, threaded, Class 125, 175 psi CWP rating, ANSI B16.4
         3). Cast iron, flanged, Class 125, 175 psi CWP rating, ANSI B16.1
         4). Carbon steel butt weld, ASTM A234 Grade WPB/American Society of Mechanical Engineers (ASME) B16.9, standard weight, seamless

5). Ductile iron or malleable iron, grooved for mechanical coupling, 175 psi CWP rating, malleable iron conforming to ASTM A47. Fitting, gasket, and coupling shall be furnished by same manufacturer.

c. Joints:

1). Threaded, tapered pipe threads, ANSI B1.20.1

2). Flanged, cast iron, 175 psi CWP rating, ANSI B16.1, square head machine bolts with semi-finished hexagon nuts, ASTM A183, neoprene gasket

3). Welded, welding electrodes shall be Lincoln or equal with coating and diameter as recommended by manufacturer for type and thickness of work being done.

4). Mechanical:

a). Grooved couplings shall be same manufacturer as used for grooved fittings.

b). Malleable iron, ASTM A47, equal to Victaulic, Style 75

c). Rigid mechanical, ASTM A-536, equal to Victaulic, Style 005

d). Wet systems gasket: Grade E EPDM gasket per UL 157 and UL 213

e). Dry systems gasket: Victaulic “FlushSeal” or equal

f). Rigid or zero flex type couplings shall be provided when operating pressures cause piping to move out of place or sway on hangers. Flexible couplings may be used where pipe is braced or clamped into rigid position.

2. Carbon Steel, larger than 2”:

a. Pipe: Carbon steel pipe, Schedule 10, ASTM A795, ASTM A53, or A135

b. Fittings:

1). Carbon steel butt weld, ASTM A234 Grade WPB/ASME B16.9, Schedule 10, seamless

2). Ductile iron or malleable iron, roll grooved for mechanical coupling, 175 psi CWP rating, malleable iron conforming to ASTM A47. Fitting, gasket, and coupling shall be furnished by same manufacturer.

a). Acceptable manufacturers: Gruvlok, Victaulic, Viking, or equal

c. Joints:

1). Welded, welding electrodes shall be Lincoln or equal with coating and diameter as recommended by manufacturer for type and thickness of work being done.

2). Cut Groove

3. Copper, 2” and Smaller:

a. Pipe: Copper tube, Type L, hard drawn, ASTM B88

b. Fittings:

1). Cast bronze, solder joint, pressure rated, ANSI B16.18

2). Wrought copper, solder joint, pressure rated ANSI B16.22

c. Joints:

1). Lead free (<0.2%) solder, Bridgit or Silvabrite, ASTM B32, flux ASTM B813

2). Brazed, silver solder, BCuP-5, AWS A5.8, 1250°F melting point minimum

d. Nipples: Red brass pipe, threaded

4. Galvanized Steel, 2” and smaller:

a. Pipe: Galvanized steel pipe, Schedule 40, ASTM A795, ASTM A53, or A135

b. Fittings:

1). Malleable iron, threaded, galvanized coating, Class 125, ANSI B16.3

2). Forged steel, threaded, galvanized coating, ANSI 16.11

3). Mechanical cut grooved couplings and fittings, galvanized coating, ASTM A123

c. Joints:

1). Manufacturers, such as Victaulic, have indicated that the alkyd coating on their mechanical couplings is a barrier against corrosion. This item usually comes up as a value engineering item or Request for Information (RFI) if you've specified galvanized couplings. Discuss with project architect if galvanized pipe is visible to the public since the orange-colored, "alkyd" coating on the mechanical couplings and the silver colored galvanized pipe presents a unique color scheme. See spec editor's notes in section of galvanized pipe larger than 50 mm(2").Tapered pipe threads, ANSI B1.20.1

2). Ductile iron or malleable iron, grooved for mechanical coupling, 175 psi CWP rating, malleable iron conforming to ASTM A47, standard ductile iron with standard alkyd coating.

a). Fitting, gasket and coupling shall be furnished by same manufacturer.

b). Dry systems gasket: Victaulic "FlushSeal" or equal

c). Acceptable manufacturers: Gruvlok, Victaulic, Viking, or equal

5. Galvanized Steel, larger than 2":

a. Pipe: Galvanized steel pipe, Schedule 10, ASTM A795, ASTM A53, or A135

b. Fittings:

1). Cast iron, threaded, galvanized coating, Class 125, ANSI B16.4

2). Forged steel, threaded, galvanized coating, ANSI 16.11

3). Mechanical cut groove couplings and fittings; galvanized coating, ASTM A123

c. Joints:

1). Tapered pipe threads, ANSI B1.20.1

2). Ductile iron or malleable iron, grooved for mechanical coupling, 175 psi CWP rating, malleable iron conforming to ASTM A47, standard ductile iron with standard alkyd coating.

a). Fitting, gasket, and coupling shall be furnished by same manufacturer.

b). Dry systems gasket: Victaulic "FlushSeal" or equal

c). Acceptable manufacturers: Gruvlok, Victaulic, Viking, or equal

6. Provide metal pipe's exposed threads with corrosion inhibitive paint, equal to Rust-Oleum.

7. Provide pipe identification system with flow directional arrows on fire protection pipe. For additional information about pipe identification, refer to Section 20 0553 – Mechanical Systems Identification.

8. Plain end couplings (Roust-A-Bouts, Plainloks or similar couplings) are not allowed on either new or existing sprinkler systems.

9. Expansion joints:

a. Provide AnvilStar Tri-Flex Loop or MetraFlex FireLoop installed per manufacturer's installation instructions.

b. Refer to structural drawings for location of expansion joints.

10. Provide high pressure expansion joints and mechanical couplings where pressures exceed 175 psi water working pressure.

11. Shop welded joints.

a. Welding electrodes shall be Lincoln or equal with coating and diameter as recommended by manufacturer for type and thickness of work being done.

2.3 VALVES

A. Gate Valve:

1. Acceptable manufacturers: Kennedy, Milwaukee Valve Co., Mueller, Nibco, Stockham, Victaulic, or equal

2. Outside screw and yoke (OS&Y), gate valve, bronze body and trim or cast iron body bronze mounted and rated for 175 psi, non-shock cold water working pressure, Nibco, F-607-OTS or equal.
3. Provide high pressure valves when pressures exceed 175 psi water working pressure.

B. Check Valve:
1. Acceptable manufacturers: Reliable, Tyco Fire Products, Victaulic, Viking, or equal
2. Iron body, bronze seat, stainless steel clapper with a replaceable rubber seal. Tyco Fire Products, CV-1F, Viking Model, G-1 or equal
3. Provide high pressure valves and fittings when pressures exceed 175 psi water working pressure.

C. Check Valve (Anti-Water-Hammer type)
1. Acceptable manufacturers: Reliable, Tyco Fire Products, Victaulic, Viking, or equal
2. Ductile iron conforming to ASTM A536, Grade 65-45-12, rust inhibiting coating, sizes 2” to 5” consisting of stainless steel clapper conforming to ASTM A-167 and for sizes 6” to 8” consisting of ductile iron clapper conforming to ASTM A-536. Equal to Gruvlok Series 78FP.
3. Provide high pressure valves and fittings where pressures exceed 175 psi water working pressure.

D. Ball Valve:
1. Acceptable manufacturers: Milwaukee Valve Co., Mueller, Nibco, Stockham, Victaulic, or equal
2. Provide high pressure valves and fittings when pressures exceed 175 psi water working pressure.

E. Double Check Detector Assembly (DCDA):
1. Acceptable manufacturers: Ames is the only acceptable manufacturer.
2. Weighted clapper double check valve assembly including 2 supervised OS&Y gate valves
3. Assembly shall be double check valve assembly for cross connection devices.
4. Certified in accordance with ASSE 1015 and AWWA C510-97
5. Double check valve shall be selected based on minimal pressure drop to allow maximum available pressure to sprinkler system.
6. Provide high pressure DCBP assembly and fittings when pressures exceed 175 psi.
7. Provide fire department connection to conduct forward test

F. Test and Drain Valves:
1. Acceptable manufacturers: AGF, Victaulic, or equal
2. AGF TESTanDRAIN, Victaulic, Style 720, TestMaster II, or equal
3. Provide high pressure valves and fittings where pressures exceed 175 psi water working pressure.

G. Drain Valves:
1. Acceptable manufacturers: Kennedy, Nibco, or equal
2. Thread-in bonnet bronze globe valves, rated to 175 psi non-shock cold water working pressure
3. Provide high pressure valves and fittings when pressures exceed 175 psi cold water working pressure.

H. Pressure Regulating Valves:
1. Acceptable manufacturers: Croker, Elkhart Brass, Potter-Roemer, or equal
2. Valve shall be able to regulate inlet pressure up to 400 psi, brass body with brass and stainless steel internal parts, field adjustable indicating scale, non-rising stem, red handwheel. Potter-Roemer, Model 4036-MSA1 or equal for in-line applications and Model 4035-MSA1 or equal for end-of-line applications.

I. Fire Department Valve (FDV):

1. Acceptable manufacturers: Croker, Elkhart Brass, Potter-Roemer, or equal
2. Fire Department valve shall be 2-1/2" angle valve, cast brass body, rough brass finish, equal to Potter-Roemer Model 4065. Valve cap for 2-1/2" valve shall be 2-1/2" x 1-1/2" hose adapter reducer Potter-Roemer, Model 2810 with 1-1/2" cap with chain, Potter-Roemer, Model 4615 or equal. Cap and chain finish shall match finish of valve body. Threads shall match Fire Department Standards.

J. Provide identification sign (enamel on metal) for valves per NFPA requirements. For additional information, refer to Section 20 0553 - Mechanical Systems Identification.

K. Valves in galvanized piping shall be bronze.

2.4 PREACTION VALVE AND ACCESSORIES

A. Acceptable manufacturers: Reliable, Tyco Fire Products, Victaulic, Viking, or equal

B. Each preaction sprinkler system shall be independent of each other and shall contain separate valves and accessories.

C. Provide high pressure preaction valve assembly where pressures exceed 175 psi water working pressure.

D. Preaction system shall be double interlocked, unsupervised system. System shall be locked and chained. The Laboratory shall provide lock and chain.

E. Piping system shall be pneumatically pressurized for supervisory purposes.

F. Valve shall be self-closing design and will not require disassembly for resetting.

G. Each system shall include:
1. Preaction valve trim
2. Pressure operated relief valve
3. Alarm pressure switch
4. Supply control valve
5. Soft seat check valve
6. Air supervisory pressure switch
7. Air supply control valve
8. Release solenoid valve
9. Air will be provided from Building Air Distribution System.
10. Emergency release
11. Microprocessor-Controlled Release Control panel with compatible Fire Detection System
12. Cross zoned with photoelectric and ionization smoke detectors.
13. Provide a manual control station (manual release) in each IBF/IT room. Locate near exit.

H. Preaction Control Panel:
1. Control panel shall communicate and be coordinated with the main Fire Alarm System.
2. Contacts shall be available so that the main Fire Alarm Control Panel can monitor the preaction system releasing panel for alarm, trouble, and supervisory signals.
3. Provide additional contacts as needed for additional auxiliary functions.

I. Provide detection system to operate preaction sprinkler system. Detection system shall be installed per 28 3113 - Fire Detection and Alarm Systems.

J. Air will be provided from Building Air Distribution System in lieu of an air compressor.

2.5 DRY PIPE VALVE

A. Acceptable manufacturers: Reliable, Tyco Fire Products, Victaulic, Viking, or equal

B. Include standard trimmings, such as gauges, drain valve, test valve, air connection, and air supervisory pressure switch.

C. Air will be provided from Building Air Distribution System.

D. Waterflow alarm bell shall be included with dry pipe valve. Waterflow alarm shall be compatible with building's fire alarm system.

2.6 FLOW SWITCH

A. Acceptable manufacturers: Potter Electric Signal Co., System Sensor, or equal

B. Vane type waterflow switch for use in wet sprinkler systems, minimum 300 psi service pressure rating, 10 gpm minimal flow rate to activate alarm, and 2 sets of SPDT (Form C) contacts. Equal to Potter Electric Signal Co., VS series.

C. Unit shall be compatible with building's fire alarm system.

2.7 WATERFLOW ALARM PRESSURE SWITCH

A. Acceptable manufacturers: Potter Electric Signal Co., System Sensor, or equal

B. Pressure actuated switch for use in dry sprinkler systems, 300 psi service pressure rating, adjustable between 4-15 psi, 2 sets of SPDT (Form C) contacts rated at 2 amps at 30 VDC and 10.1 amps at 125/250 VAC. Potter Electric Signal Co., PS series or equal.

C. Unit shall be compatible with building's fire alarm system.

2.8 WATERFLOW ALARM (EXTERIOR OF BUILDING)

A. Acceptable manufacturers: Cooper Wheelock, Potter Electric Signal Co., or equal

B. Basis of Design:
   1. Potter Electric Signal Co., 6" diameter bell with compatible weatherproof backbox. Electric bell shall comply with UL 464, Audible Signal Appliances.

C. Device shall be compatible with building's fire alarm system.

D. If required by code official, provide approved signage per NFPA 13.

2.9 SPRINKLER HEAD

A. Manufacturers:
   1. Unless otherwise noted below, shall be manufactured by Reliable, Tyco Fire Products, Viking, or equal.

B. Automatic, having temperature and pressure rating suitable for location

C. Architect will review deviations from specified styles for approval prior to installation.

D. Provide the following type of sprinkler head.
   1. Type A: Unfinished areas such as mechanical spaces, and penthouse.

a. Standard Coverage, Brass Upright or Pendent, ordinary temperature class, Tyco Fire Products, Model TY-FRB. Viking, Microfast or equal

2. Type B: In areas with ceilings
   a. Concealed Pendent, ordinary temperature class solder link, Tyco Fire Products, Model RFII, Viking, Mirage, adjustable sprinkler, with 139°F temperature class cover plate, flush with ceiling or equal. Cover plate color shall match ceiling color and shall be factory-painted (i.e. by manufacturer).
3. Type C: In areas where ceiling conditions do not permit installation of pendent head or finished area where sidewall head provides better coverage of hazard.
   a. Standard Coverage, chrome finish, sidewall, ordinary temperature class, Tyco Fire Products, Model TY-FRB, Viking Microfast, HSW horizontal or VSW vertical sidewall with Viking Microfast Model F-1 adjustable escutcheon or equal.
4. Type D: In walk-in coolers and freezers
   a. Polished chrome dry pendent, intermediate temperature class, adjustable recessed chrome escutcheon, Tyco Fire Products, Model DS-1, Viking or equal. Provide compatible wire cage sprinkler head guard where sprinklers are subject to impact damage.

E. Submit samples for examination and approval when appearance is different than sprinkler head specified.

F. Temperature class of sprinkler heads shall vary if installed close to heat sources, under skylights or in special hazard areas. Refer to NFPA 13 for requirements.

G. Provide high pressure sprinklers where pressures exceed 175 psi working water pressure.

H. Sprinkler Cabinets:
   1. Shall be complete with required number of spare sprinkler heads of each type and temperature rating per NFPA 13
   2. Shall be provided with at least one sprinkler wrench for each type of sprinkler installed
   3. Provide multiple cabinets to meet this requirement.
   4. Coordinate cabinet locations with Laboratory's representative.

2.10 FIRE VALVE CABINETS (FVC)

A. Manufacturers:
   1. Acceptable Manufacturers: American Fire Hose & Cabinet, Badger-Powhatan, Croker Corp., Elkhart Brass, Fire End, Guardian Fire Equipment, Potter-Roemer, or equal

B. Fire Valve Cabinets:
   1. FVC-1
      a. Cabinet: Surface Mounted, Potter-Roemer, series 1815 or equal
      b. Door Style: Solid Metal, white polyester coating with identifying decal
      c. Angle Valve: Female x Male 2 ½” cast brass, polished chrome plated finish with threads to match local Fire Department Standards. Potter-Romer 4065 or equal.

2.11 FIRE DEPARTMENT CONNECTION (FDC)

A. Manufacturers:
   1. Acceptable Manufacturers: Badger-Powhatan, Croker Corp., Elkhart Brass, Potter-Roemer, Tyco Fire Products, or equal

B. Fire Department Connection:

1. Provide freestanding Storz type, cast brass body with drop clappers, faceplate shall be polished brass finish, with lettering reading AUTOSPKR STANDPIPE.
2. Unit shall include 2 2-1/2” snoots with rigid end threading to match local fire department standards by pin-lug hose thread swivels, pin-lug plugs and chains. Finish of snoots shall match faceplate finish. Provide Elkhart Brass or equal.
3. Coordinate location with the Laboratory Fire Department.
4. Provide protection around fire department connection such as bollards to avoid potential damage.

C. Fire Department Connection:
1. Provide flush type, cast brass body with drop clappers, faceplate shall be polished brass finish, with lettering reading DOUBLE CHECK DETECTOR FORWARD TEST.
   a. Final lettering shall be approved by Laboratory Fire Department
2. Unit shall include 2 2-1/2” snoots. Finish of snoots shall match faceplate finish. Provide Elkhart Brass or equal.
3. Final location shall be coordinate with Laboratory Fire Department.

2.12 BALL DRIP

A. Acceptable manufacturer: Potter-Roemer, Reliable, Tyco Fire Products, or equal

B. Provide bronze ball drip at the bottom of fire department connection (FDC).

2.13 HANGERS

A. Acceptable manufacturers: Afcon, Anvil, B-Line, Tolco, or equal

B. Concrete expansion hangers, when provided, are to be Hilti, Phillips, Powers, or equal

C. Hanger rods shall comply with Manufacturer Standardization Society (MSS) standards and manufacturer’s published load rating.

D. Provide hanger rod, hanger rod attachments, bolts, u-bolts, nuts, studs and washers with electroplated zinc coating or with hot-dipped galvanized finish.

E. Riser clamps shall be electroplated zinc coated or have a hot-dipped galvanized finish and shall not protrude more than 2” beyond edge of hole. Provide Anvil Fig. 261 or equal.

2.14 PRESSURE GAUGES

A. Acceptable manufacturers: Ashcroft, Potter-Roemer, Viking, or equal

B. Pressure gauges shall be 3-1/2”, corrosion resistant moving parts, polycarbonate window, and provided with connection not smaller than 1/4” NPT.

C. Include ball valve with provisions for draining on each pressure gauge.

PART 3 - EXECUTION

3.1 DESIGN CRITERIA

A. Flow Test:
1. Static Pressure: 61 psig
2. Residual Pressure: 58 psig with 1836 gal flowing per minute

3. Flowing hydrant H-400-20 and pressure-test hydrant H-400-19 are located at Building 435 (APS ring).
4. Test Date: Tuesday, November 15, 2011
5. Test Time: 1:30pm
6. Elevation of pressure-test hydrant: Unknown
7. Test conducted by or information supplied by: V. Kunkler, FPE &, J. Johnson, Util. Foreman

B. Sprinkler Contractor, prior to preparation of installation drawings and hydraulic design calculations, shall conduct a hydrant flow test within the last 12 months.

C. Send current hydrant flow test data to Engineer.

D. Hydraulically calculated system shall be designed for a water supply pressure of at least 10% but not less than 10 psi below the available water flow curve.

E. Systems that are hydraulically calculated must include 1.2 factor for design area.

F. Basis of Design:
1. Administrative and office areas shall be hydraulically designed to provide a minimum density of 0.15 gpm per square foot over the most hydraulically remote 1500 sq ft. Maximum spacing shall not exceed 130 sq ft per head.
2. Laboratory areas shall be hydraulically designed to provide a minimum density of 0.20 gpm per square foot over the most hydraulically remote 2500 sq ft. Maximum spacing shall not exceed 130 sq ft per head.
3. Penthouse (mechanical room) shall be hydraulically designed to provide a minimum density of 0.20 gpm per square foot for the most remote 2500 sq ft. Maximum spacing shall not exceed 130 sq ft per head.
4. The loading dock area shall be hydraulically designed to provide a minimum density of 0.15 gpm per square foot over the most hydraulically remote 1500 sq ft. Maximum spacing shall not exceed 130 sq. ft. per head.

G. Hose Streams:
1. Add 250 gpm hose stream to sprinkler zone hydraulic calculations for Ordinary Hazard Occupancies.

H. Fire Protection System Layout and Installation Drawings:
1. Contractor shall review Design Drawings and Specifications, and shall provide installation drawings, calculations, and product data sheets.
2. Layout of fire protection system has been established as it relates to structure, and mechanical/electrical systems in building, and must be adhered to. Other layouts shall be produced by Contractor in coordination with building components.
3. Conceal sprinkler piping above ceilings where possible.
4. Contractor shall consult with Architect during development of piping layout to avoid conflicts with general appearance. Pipe routing is a critical issue due to attributes of this building.
5. Submit stamped and sealed installation drawings, calculations and product data sheets for coordination review to: architect, insurance carrier, City of Argonne and other Authorities Having Jurisdiction prior to installation (see submittals).
6. Contractor shall be responsible to have examined "Reflected Ceiling" drawings as well as Mechanical, Electrical, Piping, Information Technology, Structural and Architectural building plans prior to system layout.
7. Contractor shall coordinate routing of piping with other trades and Architect.
8. Contractor shall participate in coordination process and shall not install piping prior to coordination with other trades.

3.2 INSPECTION

A. Investigate site conditions; verify utility locations and elevations before start of excavation. Forward discrepancies to Architect/Engineer before proceeding with construction.

3.3 INSTALLATION

A. Install hydraulically designed sprinkler system and associated accessories according to requirements of NFPA 13 and as shown on drawings.

B. Install hydraulically designed a manual standpipe system and associated accessories according to requirements of NFPA 14 and as shown on drawings.

C. Install pipe, fittings, couplings, and valves according to requirements of manufacturer.

D. Keep materials within listed temperature range to assure jointing in accordance with manufacturer's requirements.

E. Pipe and fittings shall be of corresponding materials when assembled.

F. Below Ground Pipe:
   1. Anchors and tie rods can be provided in lieu of thrust blocks. Tie rods shall be 3/4” diameter steel rod. Clamps shall be 3/8” thick by 2” wide steel. Each clamp shall be secured with four 5/8” diameter bolts.
   2. Apply asphaltum or approved corrosion inhibitive paint, to tie rods, clamps and bolts of underground pipe.
   3. Provide metallic bond at each joint of ductile iron and cast iron pipe. Bond wire shall be type RHW-USE size 1/0 neoprene-jacketed copper conductor shaped to stand clear of joint.

G. Above Ground Pipe:
   1. Provide pipe identification system with flow directional arrows on fire protection pipe in accordance with manufacturer’s installation instructions. For additional information, refer to Section 20 0553 – Mechanical Systems Identification.
   2. Coat exposed threads with corrosion inhibitive paint, equal to Rust-Oleum. Apply paint per manufacturer’s instructions.

H. Provide readily removable fittings at end of cross-mains. Minimum size of flushing connection shall be 2”.

I. Provide test connection for each flow switch.

J. Discharge test connections inside building to receptacles provided as part of plumbing system. Drain shall be part of the lab sewer system. Outside discharge shall not be allowed.

K. Drain line detailed adjacent to standpipe/sprinkler risers shall be considered as part of Sprinkler System from combination test/auxiliary drain valve for each zone or sub-zone shown on plans to plumbing receptacle.

L. Provide auxiliary drains at low points of systems per requirements of NFPA 13.

M. Identify valve with brass tag denoting which flow switch is being tested, when test valves are located remote from flow switch.

N. Clamp-on or saddle type fittings are not allowed. Outlet fittings inserted into holes drilled into piping or pipe-o-lets are not allowed.

O. Provide reducing fittings or provide shop fabricated weld-o-lets to change pipe sizes in sprinkler/standpipe systems. No bushings or grooved reducing couplings, such as Victaulic, Style 750, are allowed.

P. Piping and fittings between preaction or dry pipe valves and sprinkler heads and test/auxiliary drain piping of dry sprinkler systems shall be galvanized steel or copper to retard or eliminate corrosion due to oxidation in these sub-systems. Provide dielectric fittings between dissimilar pipe materials.

Q. Feed sprinkler heads, installed in finished ceilings, with swing joint, or return bend arrangement for final positioning in ceiling grid pattern during construction phases.

R. Sprinklers are required to be installed in the center of ceiling tiles.

S. Provide minimum 1” outlets with sprigs or drops for sprinklers located in shelled spaces.

T. Install locks and chain on each shutoff valve. The Laboratory shall provide locks and chain.

U. Install sprinkler heads as recommended by manufacturer. Sprinklers shall be set level and at locations to avoid interference with spray pattern of sprinkler. When ducts and lights are obstructions to sprinkler distribution, provide additional heads beneath obstruction.

V. Make joints of threaded pipe by cutting pipe square and reaming inside.

W. Use joint compound sparingly.

X. Install joints for mechanical coupled pipe according to manufacturer's recommendations. Use manufacturer’s gasket lubricant sparingly.

Y. Pipe grooving shall be per coupling manufacturer’s instructions.

Z. Welded joints shall be made in fabrication shop. No welding allowed at project site.

AA. Hangers, Bracing, and Restraint of System Piping:

1. Provide hangers and associated parts to support piping in perfect alignment without sagging or interference, to permit free expansion and contraction, and meet requirements of NFPA 13 and manufacturer’s installation instructions.
2. Select and size building attachments per Manufacturer Standardization Society (MSS) standards and manufacturer’s published load rating.
3. Coordinate hanger support installation to group piping of all trades.
4. Hang pipe from building members using either concrete inserts for concrete construction or beam clamps for steel construction. Installation shall comply with manufacturer’s installation instructions. Expansion type inserts may be used for branch piping.
5. Restraining clips/clamps are required in locations where vibration may be a concern. Refer to Section 23 0550 – Vibration Isolation, for additional information regarding restraining clips/clamps.
6. Suspend hangers by means of electroplated zinc or hot-dipped galvanized finish hanger rods. Perforated band iron and flat wire straps (strap iron) are not allowed.
7. Mains parallel to joists shall not be supported from a single joist. Mains parallel to joists shall be supported by trapeze hanger and be positioned equally between two joists. Trapeze hangers shall be positioned to load joists at panel points only.
8. Support pipe from top flange of joists and beams.
9. Do not support equipment or piping from metal roof deck.

BB. Support piping in accordance with NFPA 13.

CC. Install flexible fitting at building’s expansion joints per manufacturer’s instructions.

DD. Install pressure gauges as required in manufacturer's installation instructions, and as required per NFPA standards.

EE. Generally install capped tees in lieu of couplings for future connections.

3.4 CLEANING

A. Flush sprinkler system to purge cutting oil, debris and metal fines.

B. Ensure underground feed pipe has been flushed per NFPA 24 Installation of Private Fire Service Mains and Their Appurtenances, to clear out construction debris, prior to connecting aboveground fire protection system to it.

3.5 TESTING

A. Refer to testing paragraph of Section 20 0000 - General Mechanical Requirements.

B. Perform all NFPA required acceptance tests.

C. Test sprinkler system as entire system or partial system. System shall be hydrostatically tested at not less than 200 psi or 50 psi above static pressure in excess of 150 psi for 2 h. No leakage allowed. Replace defective joints with new materials. No caulking of defective joints allowed. Re-test system after defective joints are replaced, until satisfactory results are obtained.

D. Hydrostatically test piping between the exterior fire department connection (FDC) and the check valve in the fire department inlet pipe in the same manner as the balance of the system.

E. Pipe shall not be concealed until satisfactorily pressure tested.

F. In addition to hydrostatic test, preaction and dry pipe systems shall be air pressure tested at 40 psi for 24 h. Leakage in excess of 1-1/2 psi during 24 h will not be permitted.

G. Conduct drain test. Record static pressure and residual pressure per NFPA 13.

H. Laboratory's representative or engineer may witness tests. Contractor shall notify Laboratory and Engineer a minimum of 3 days in advance to allow for participation.

I. Log of tests shall be kept at job site and shall identify:
   1. Who performed test
   2. Time of test
   3. Date of test
   4. Section of system tested
   5. Results of test
   6. Completed Contractor's Material and Test Certification form(s) from NFPA 13 and NFPA 14.

J. Operate flow switches to test that signals are transmitted to Fire Alarm Control Panel.

End of Section

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SECTION 22 00 00

GENERAL PLUMBING REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Specification requirements defined in Division 20 of this Specification apply to, and are in addition to the work associated with equipment, systems, materials, and installation requirements specified in Division 22. Contractor shall provide the requirements specified in Division 20 to obtain complete systems, tested, adjusted, and ready for operation.

1.2 RELATED WORK

A. Section 20 00 00 - General Mechanical Requirements

B. Section 20 05 13 - Motors

C. Section 20 05 14 - Variable Frequency Drives

D. Section 20 05 20 - Excavation and Backfill

E. Section 20 05 29 - Mechanical Supporting Devices

F. Section 20 05 53 - Mechanical Systems Identification

G. Section 20 05 73 - Mechanical Systems Firestopping

H. Section 20 07 00 - Mechanical Systems Insulation

PART 2 - PRODUCTS

2.1 NOT APPLICABLE TO THIS SECTION.

PART 3 - EXECUTION

3.1 NOT APPLICABLE TO THIS SECTION.

End of Section

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SECTION 22 11 18

WATER DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section covers interior domestic cold water, domestic hot water (120°F), domestic hot water return, laboratory cold water, laboratory hot water (120°F), laboratory hot water return tempered water, nonpotable cold water and to a point 5 ft outside building wall.

1.2 RELATED WORK

A. Section 20 05 13 - Motors

B. Section 20 05 14 - Variable Frequency Drive (VFD) Systems

C. Section 20 05 20 - Excavation and Backfill

D. Section 20 05 29 - Mechanical Supporting Devices

E. Section 20 05 53 - Mechanical Systems Identification

F. Section 20 07 00 - Mechanical Systems Insulation

G. Section 22 05 94 - Domestic Water Systems Balance

H. Section 22 21 14 - Plumbing Specialties

I. Section 26 29 13 - Enclosed Controllers

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.4 QUALITY ASSURANCE

A. Order pipe with each length marked with manufacturer's name or trademark and type of pipe; with each shipping unit marked with purchase order number, metal or alloy designation, temper, size, and supplier's name.

B. Installed material not meeting specification requirements must be replaced with material that meets these Specifications without additional cost to Laboratory.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Promptly inspect shipments to ensure material is undamaged and complies with specifications.

B. Cover pipe to prevent corrosion or deterioration while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends from damage. End caps shall remain in place. Protect fittings, flanges, and unions by storage inside or by durable, waterproof, above ground packaging.

C. Offsite storage agreements will not relieve Contractor from using proper storage techniques.

D. Storage and protection methods must allow inspection to verify products.

1.6 SUBMITTALS

A. Manufacturer's technical data for the following:
   1. Pipe
   2. Fittings
   3. Joints
   4. Valves
   5. Unions and Flanges
   6. Dielectric fittings
   7. Water hammer arrestors
   8. Expansion joints
   9. In-line Centrifugal Pumps

B. Shop Drawings on items specified herein.

C. Where loads imposed exceed design superimposed dead loads or hanging loads specified in contract documents, submit for approval to Structural Engineer of Record loads imposed on the primary structural frame. Submittal shall include location magnitude and direction of imposed loads (basic, unfactored load cases), graphically represent in their appropriate locations on a copy of the Contract Document structural framing plans or elevations as appropriate. Detail reference indicating the connections applicable at each location shall be noted on the submittal drawings.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials as specified shall be new unless otherwise noted.

2.2 PIPE, FITTINGS, AND JOINTS

A. Pipe, fittings, and joints for Water Main to 2 ft above finished floor

B. Underground 2-1/2" and Smaller:
   1. Copper:
      a. Pipe: Copper tube, Type K, soft (annealed) temper, ASTM B88
      b. Fittings: Copper pressure fittings, ANSI B16.18; wrought copper pressure fittings, ANSI B16.26
      c. Joints: Lead free (<0.2%) solder, ASTM B32, flux, ASTM B813

C. Underground 3" and Larger:
   1. Ductile Iron:
      a. Pipe: Ductile iron, Class 52, AWWA C151, with standard cement mortar lining, AWWA C104
      b. Fittings:
         1). Ductile iron or grey iron, mechanical joint, cement mortar lined, Class 250, AWWA C110
         2). Ductile iron, mechanical joint compact fittings, Class 350, AWWA C153
      c. Joints: elastomeric gasket joints with non-toxic gasket lubricant, AWWA C111
      d. Encasement: provide 8 mil tube or sheet polyethylene encasement of iron pipe and pipe fittings, AWWA C105

2. Polyvinyl Chloride (PVC):
   a. Pipe:
      1). PVC pressure pipe, DR 18, Class 150, AWWA C900; integral bell and elastomeric gaskets, ASTM D3139
      2). PVC pressure pipe, Schedule 80, ASTM D1785, AWWA C900
   b. Fittings:
      1). Ductile iron or grey iron, mechanical joint, cement mortar lining, AWWA C104
      2). Ductile iron, mechanical joint compact fittings, Class 350, AWWA C153
      3). PVC, Schedule 80, socket pattern
   c. Joints:
      1). Elastomeric gaskets, ASTM C3139
      2). Primer, ASTM F656; solvent cement, ASTM D2564

D. Above Ground:
1. Copper (2-1/2” and Smaller):
   a. Pipe: Copper tube, Type L, hard drawn, ASTM B88
   b. Fittings:
      1). Cast bronze, solder joint, pressure rated, ANSI B16.18
      2). Wrought copper, solder joint, pressure rated, ANSI B16.22
   c. Joints:
      1). Lead free (<0.2%) solder, ASTM B32, flux, ASTM B813
   d. Nipples: Red brass pipe, threaded
   e. Exposed tubing and fittings in kitchen and areas subject to chemical cleaning shall have chrome plated finish.
2. Copper (3” and Larger):
   a. Pipe: Copper tube, Type L, hard drawn, ASTM B88
   b. Fittings:
      1). Cast bronze, solder joint, pressure rated, ANSI B16.18
      2). Wrought copper, solder joint, pressure rated, ANSI B16.22
   c. Joints: Brazed, BcuP-5 type, AWS A5.8, 1250°F minimum melting point

2.3 UNIONS AND FLANGES

A. General:
1. Unions, flanges and gasket materials to have pressure rating of not less than 150 psig at 180°F.

B. Copper (3" and Smaller):
1. Wrought copper union, Nibco Figure 733. Mueller Brass equal.

C. Copper (4" and Larger):
1. Cast red brass flanges, alloy 844, ASTM B584, Class 150, Standard bolt pattern, ANSI B16.24 with neoprene gasket

D. Copper (3” and Larger):
1. Ductile iron flange adapters, ASTM A 536, coated with copper-colored enamel for use with grooved end pipe and fittings, flat face, manufactured for engaging directly into roll grooved copper tube and fittings and bolting directly to flanged components with ANSI Class 125 and 150 bolt hole patterns, EPDM gasket. Victaulic Style 641.

2.4 VALVES

A. Shutoff Valves:

1. Ball Valves:

   a. Acceptable manufacturers: Apollo, Crane, Hammond, Milwaukee, Nibco, Stockham and Watts with indicated features and equal to model listed. Note that not all manufacturers make all sizes.

   b. Full Port, 2 Piece: Bronze body, ASTM B584, stainless steel ball and stem, teflon seats, stem extension, 600 psi CWP pressure rating, Apollo Series 77 240.

   c. Full Port, 3 Piece: Bronze body, ASTM B584, stainless steel ball and stem, teflon seats, stem extension, 600 psi CWP pressure rating, Apollo Series 77 240.

   d. Insulated Handle: For insulated systems to prevent condensation on valve body with thermal and vapor seal, equal to Nibco Nib Seal.

2. Butterfly Valves:

   a. Acceptable Manufacturers: Apollo, Crane, Hammond, Milwaukee, Nibco, and Stockham with indicated features and equal to model listed. Note that not all manufacturers make all sizes or styles.

   b. Threaded or Solder Ends: Bronze body, stainless steel disc and stem, viton disk seal, Milwaukee Series BB2

   c. Lug Type: Ductile iron body, aluminium bronze disc, EPDM liner, 316 stainless steel stem, brass bushings (lower, upper and collar), 200 psi CWP pressure rating, lever handle through 6", gear operator 8" and larger, Crane Quartermaster 44-B-S-Z

   d. Swing Check Valves:

3. Size 3" and Smaller:

   a. Bronze body, ASTM B62, Y pattern, Buna-N resilient disc, horizontal swing, 200 psi CWP rating, Nibco 413

4. Valves 4" and Larger:

   a. Iron body, horizontal swing, cast bronze disc and seat, 200 psi CWP rating, Nibco F-918

B. Balancing Valves:

1. Circuit Setter:

   a. Acceptable Manufacturers: Armstrong, Bell and Gossett, Griswold or Taco

   b. 2” and Smaller: Shall be of bronze construction with glass and carbon-filled TFE seat rings and have differential pressure read-out ports across valve seat area. Read-out ports to be filled with internal EPT insert and better connection with check valve. Valve bodies to have 1/4" NPT tapped drain/purge port. Valves to have memory stop feature and calibrated nameplate to assure specific valve setting. Valve to be leak-tight at full-rated working pressure and temperature (300 psi/250°F). B&G Circuit Setter Model CB, Griswold Speedsetter or approved equal.

C. Mixing Valves

1. MV-1 Thermostatic Point of Use Tempered Water mixing Valve

   a. Acceptable manufacturers: Lawler, Leonard, Powers or approved equal

   b. Master emergency fixture thermostatic mixing valve, capable of maintaining mixed water temperature within 5°F of setpoint. Valve shall fail to cold water supply only on loss of hot water supply. Valve shall fail closed on loss of cold water supply.

   c. Mixing valve shall be bronze construction with dual thermostatic elements, high temperature limit stop, locked temperature regulator and integral thermometers on inlet, outlet and mixed water lines. Valve shall be rated for 125 psig operating pressure and be certified per ANSI A358.1 requirements.

d. Valve shall have 120°F hot water inlet, 40°F cold water inlet and 85°F mixed water temperature with peak mixed water flow of 20 gpm. Leonard TM-650 or equal.

2.5 DIELECTRIC FITTINGS

A. Insulating nipple, metal casing, inert thermoplastic lining, Clearflow dielectric fitting by Perfection Corporation or Victaulic Style 47.

B. Dielectric unions 2" and smaller; dielectric flanges 2-1/2" and larger; with iron female pipe thread to copper solder joint or brass female pipe thread end connections, non-asbestos gaskets and pressure rating of not less than 175 psig at 180°F. Watts Regulator Company, Lochinvar, Wilkins or Epco Sales, Inc.

2.6 WATER HAMMER ARRESTORS

A. Mechanical Water Hammer Arrestors:
1. Piston-compressed air column type, with sealed air chamber.
2. Manufacturers: Watts, Sioux-Chief, and Precision Plumbing Products (PPP), Inc., equal to size shown. Provide access panels when mechanical shockstops are installed in non-accessible concealed locations.

2.7 EXPANSION JOINTS/LOOPS

A. Galvanized steel pipe, Schedule 40, with mechanical couplings, Victaulic 150 Mover

B. Copper Piping:
1. Use expansion loops where space is available. Size expansion loops as listed in the following table:

Pipe Size	Length of Each Loop	Number of Legs
3/4"	38"	3
1"	40"	3
1-1/4"	42"	3
1-1/2"	46"	3
2"	50"	3
2-1/2"	54"	3
3"	60"	3
4"	68"	3

C. Copper Piping:
1. Mechanical expansion fittings, size 3/4" thru 4", copper tube sweat ends, stainless steel laminated internal bellows, 200 psig working pressure, 600°F rated; Keflex Model 7QT.
2. Allowable length of copper tube per mechanical expansion fitting shall be in accordance with the following table:

System Operating Temperature	Length of Pipe
110°F	300 ft
120°F	275 ft
130°F	250 ft
140°F	225 ft
150°F	175 ft
160°F	175 ft

System Operating Temperature	Length of Pipe
170°F	150 ft
180°F	140 ft

D. Pre-manufactured expansion loop will be allowed: Metraflex Model MLS Series for sweat ends, MLT Series for threaded ends and MLF Series for flanged or groove ends. Verify pipe size required, laying length, and face-to-face dimension required. Coordinate location with other trades.

2.8 IN-LINE CENTRIFUGAL PUMPS FOR TEMPERATURE MAINTENANCE OF LABORATORY HOT WATER

A. Manufacturers: Armstrong, Aurora, Bell and Gossett, Deming, Ingersoll-Rand, Taco, Weinman, or Worthington

B. Pumps shall be pipeline mounted, single suction type with cast iron casing, bronze fitted with working pressure of 150 psi and operating temperature of 225°F continuous, 250°F intermittent.

C. Impellers shall be steel and shall be directly hung from motor shafts without using flexible couplings.

D. Pump shafts shall be steel or stainless steel, sealed and gasketed from pumped fluid.

E. Pumps shall be furnished with mechanical carbon/silicon carbide seals.

F. Bearing assemblies and motor shall be permanently oil lubricated and maintenance free.

G. Pump shall be controlled by adjustable programmable time clock similar to Bell and Gossett TC-1 timer kit..

H. Refer to Section 26 2913 - Enclosed Controllers.

2.9 DOMESTIC WATER SERVICE METER

A. Manufacturers: Badger Meter or approved equal.

B. Meter shall be turbine type conforming to AWWA C701. Meter register may be round or straight reading type, indicating total gallons. Meter shall be provided with a pulse generator, remote readout register and all necessary wiring and accessories.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pipe and fittings in accordance with reference standards, manufacturer's recommendations and recognized industry practices.

B. Maintain piping system in clean condition during installation. Remove dirt and debris from assembly of piping as work progresses. Cap open pipe ends where left unattended or subject to contamination.

C. Include connections to plumbing fixtures, to equipment by others, and to equipment requiring water. Provide proper backflow and back siphonage protection to safeguard potable water system from contamination.

D. Lay out water system so as to conform to intent of drawings. Coordinate piping with building features and work of other trades. Plans indicate, general routing, provide additional offsets as required. Install piping with necessary swing joints and offsets to allow for expansion. Install shut-off valves on branch lines near mains to avoid long dead-leg branches when valves are closed. Install water piping plumb and square with building. Pitch water pipe to drain with drain valves at low points.

E. Install shut-off valves where indicated and at base of risers to allow isolation of portions of system for repair. Do not install water piping within exterior walls.

F. Provide protective sleeve covering of elastomeric pipe insulation where copper or steel piping is embedded in masonry or concrete.

G. Provide dielectric fittings between dissimilar piping materials.

H. Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including required service space for this equipment, unless piping is serving this equipment.

I. Install valves and piping specialties, including items furnished by others, as specified and/or detailed. Provide access to valves and specialties for maintenance. Make connections to equipment, fixtures and systems installed by others where same requires piping services indicated in this Section.

J. Install water pipe using proper pipe and fittings. Use reducing fittings for changes in pipe size.

K. Install trap filler lines to slope to drain tailpiece without trapping.

3.2 UNDERGROUND WARNING TAPE

A. Provide warning tape for exterior buried utilities per Section 20 0553.

3.3 COPPER PIPE

A. Threaded Pipe Joints:
   1. Make threaded pipe joints with square cut and reamed pipe. Provide tapered pipe threads in conformance with ANSI B1.20.1.
   2. Cut threads so that exposed threads at joint are less than 3. Coat exposed threads with corrosion inhibiting paint. Use joint compounds or teflon tape on pipe threads to achieve leak free joint.

B. Soldered Copper Pipe Joints:
   1. Use non-acidic and lead free flux on cleaned pipe and fittings for soldered joints.
   2. Cut tube square, remove burrs from exterior of tube and ream interior of tube before assembly.
   3. Fill joints with solder by capillary action. Solder shall cover joint periphery. Wipe joint clean.
   4. Apply heat carefully to prevent damage to pipe, fittings and valves.
   5. Follow manufacturer's recommendations when heating valves and equipment for soldered connections.

3.4 WATER HAMMER ARRESTORS

A. Use water hammer arrestors to control water hammer. Installed devices shall be sized and located according to manufacturer's recommendations, PDI Standards, or as shown on drawings.

B. Use water hammer arrestors with flush valves, quick-closing valves, and at branch main risers serving more than 1 fixture.

C. Provide access panels when water hammer arrestors are installed in non-accessible concealed locations.

3.5 DIELECTRIC UNIONS AND FLANGES

A. Install dielectric unions or flanges at points where copper-to-steel pipe connection is required in domestic water systems.

B. Install unions on equipment side of shutoff valves for items such as: water heaters, water softeners, pumps, filters, and similar equipment requiring periodic replacement.

3.6 EXPANSION JOINTS

A. Install one anchor on either side of expansion joint, opposite direction of expansion.

B. Install pipe guides on each side of mechanical expansion fittings.

3.7 VALVE ACTUATORS

A. Install chain operators on gate and butterfly valves (2-1/2" and larger).

3.8 CLEANING

A. Flush and clean piping prior to testing. Remove corrosion by mechanical or chemical means. Use chemicals that are non-toxic.

3.9 TESTING

A. Refer to Testing paragraph of Section 20 0000 - General Mechanical Requirements.

B. Water test system may be applied to system in its entirety or in sections. Test piping with water to pressure of 100 psi for 2 h. No decrease in pressure allowed. Provide pressure gauge with shutoff and bleeder valve at highest point of system tested. Inspect joints in system under test.

C. Defective work or material shall be replaced or repaired as necessary and inspection and test repeated. Repairs shall be made with new materials. No caulking of threaded joints or holes will be allowed.

D. Do not conceal pipe until satisfactorily tested.

E. Testing with air will not be allowed.

3.10 DISINFECTION

A. Disinfect water piping in the following manner:
   1. Clean and flush water pipe with water until water at remote tap is clear.
   2. Fill water systems with solution containing 50 ppm of chlorine (minimum concentration). Allow solution to stay in water system for 24 h. Alternately use solution of 200 ppm of chlorine (minimum concentration) for 3 h.
   3. Flush water system of chlorine solution.
   4. Allow clean water to stand in system for 24 h. Take sample from remote tap for bacteriological test.

B. Do not use water system for potable water supply until safe bacteriological test is obtained. Repeat steps 1 through 4 until safe water system is obtained.

3.11 BACTERIOLOGICAL TESTS

A. Take representative water samples and test to ensure bacteriologically safe water supply system. Include HPC (Heterotrophic Plate Count) test and test for presence of Pseudomonas aeruginosa as well as regular coliform bacteria test. HPC test maximum containment level of 500 organisms/ml. Perform bacteriological tests shortly before Laboratory's acceptance of building. If tests fail, make corrections and retest.

B. When connecting to existing water supply of unknown quality, sample for analysis and comparison with finished water system analysis shall be taken prior to making new connection. This will allow isolating

source of contamination from within scope of work or pre-existing water supply. Final conditions shall meet criteria specified above for areas within scope of work.

End of Section

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SECTION 22 13 14

SANITARY WASTE AND STORM DRAINAGE SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes materials and methods for sanitary waste and vent, clearwater waste and vent, storm drainage, and overflow storm drainage piping systems within and including piping to 5 ft outside building wall.

1.2 RELATED WORK

A. Section 20 05 13 - Motors

B. Section 20 05 20 - Excavation and Backfill

C. Section 20 05 29 - Mechanical Supporting Devices

D. Section 20 07 00 - Mechanical Systems Insulation

E. Section 22 21 14 - Plumbing Specialties

F. Section 22 40 00 - Plumbing Fixtures

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.4 QUALITY ASSURANCE

A. Order piping with each length marked with manufacturer's name or trademark and type of pipe; with each shipping unit marked with purchase order number, metal or alloy designation, temper, size, and supplier's name.

B. Installed material not meeting specification requirements must be replaced with material that meets these specifications without additional cost to Laboratory.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Promptly inspect shipments to insure material is undamaged and complies with Specifications.

B. Cover pipe to prevent corrosion or deterioration while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends from damage. End caps shall remain in place. Protect fittings by storage inside or by durable, waterproof, above ground packaging.

C. Offsite storage agreements will not relieve Contractor from using proper storage techniques.

D. Storage and protection methods must allow inspection to verify products.

1.6 SUBMITTALS

A. Manufacturer's technical data for the following:

1. Pipe and fittings

2. Joints
3. Cleanouts
4. Floor drains and floor sinks
5. Roof drains
6. Downspout nozzles
7. Air gap fittings
8. Traps

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials herein specified shall be new, unless otherwise noted.

2.2 PIPE, FITTINGS, AND JOINTS

A. Interior Underground 15" and Smaller:
1. Cast Iron:
a. Pipe: Hub and spigot pipe, service weight, ASTM A74, NSF certified with material test reports from 3 dates selected by Engineer marked with collective trademark of Cast Iron Soil Pipe Institute or receive prior approval by Engineer
b. Fittings: Hub and spigot fittings, service weight, ASTM A74, NSF certified with material test reports from 3 dates selected by Engineer marked with collective trademark of Cast Iron Soil Pipe Institute or receive prior approval by Engineer
c. Joints: Neoprene rubber compression gaskets, ASTM C564

B. Interior Above Ground:
1. Cast Iron:
a. Pipe: Hubless cast iron pipe, ASTM A-888, CISPI 301, NSF certified with material test reports from 3 dates selected by Engineer marked with collective trademark of Cast Iron Soil Pipe Institute or receive prior approval by Engineer
b. Fittings: Hubless cast iron fittings, ASTM A-888, CISPI 301, NSF certified with material test reports from 3 dates selected by Engineer marked with collective trademark of Cast Iron Soil Pipe Institute or receive prior approval by Engineer
c. Joints:
1). Heavyweight Couplings: No-hub couplings with 0.060" thick stainless steel clamps, FM 1680 Class 1, ASTM Standard C-1540 Mission Heavyweight, Husky Series 4000 or Clamp-All Hi-Torq 125

C. Adaptor Couplings for Joining Dissimilar Pipe Materials:
1. Acceptable Manufacturers: Fernco, Mission,
2. 1" through 6" diameter: Fernco Proflex 3000 Series shielded coupling with neoprene gasket, stainless steel shield, and stainless steel clamping bands. Adaptor couplings shall be specifically designed for pipe materials being joined.
3. 8" through 27" diameter: Fernco 1000 Series flexible coupling with elastomeric PVC or neoprene gasket and stainless steel clamping bands. Adaptor couplings shall be specifically designed for pipe materials being joined.

2.3 CLEANOUTS

A. Josam, Mifab, Smith, Wade, Watts or Zurn, equal to number listed in Drains and Cleanouts Schedule.

B. Provide recessed, solid brass, cleanout plugs where fittings are used as cleanouts. Provide taper-thread plug with Teflon tape thread wrap.

2.4 FLOOR DRAINS

A. Josam, Mifab, Smith, Wade, Watts or Zurn, equal to number listed herein or in Drains and Cleanouts Schedule.

B. Floor drains shall be in accordance with ANSI A112.21.1. Provide with caulked or no-hub connection. Floor drains shall have internal seepage collar for embedding in floor construction and weep holes to provide adequate drainage to drain pipe. Include trap primer connection where indicated on drawings.

2.5 FLOOR SINKS

A. Josam, Mifab, Smith, Wade, Watts or Zurn, equal to number listed herein or in Drains and Cleanouts Schedule.

B. Floor sink shall be in accordance with ANSI A112.21.1. Provide with caulked or no-hub connection. Double drainage pattern floor sink shall have anchoring and seepage flanged for embedding in floor construction and weep holes to provide adequate drainage to drain pipe. Include trap primer connection where indicated on drawings.

2.6 ROOF DRAINS AND OVERFLOW DRAINS

A. Josam, Mifab, Smith, Wade, Watts or Zurn, equal to number listed in Drains and Cleanouts Schedule

B. Roof drains and overflow drains shall have cast iron body with adjustable collar, cast iron flashing ring, gravel stops, 10" diameter cast iron dome strainer, and cast iron underdeck clamp. J.R. Smith 1010Y-RC-CID.

C. Expansion joints shall be cast iron joint with bronze pipe sleeve and neoprene gasket. J.R. Smith 1710.

2.7 AIR GAP FITTINGS

A. Air gap fittings constructed of cast iron with integral air gap having free area of at least twice the inlet area. Josam, Mifab, Smith, Wade, Watts or Zurn, equal to J.R. Smith 3950 or 3951.

2.8 DOWNSPOUT NOZZLES

A. Acceptable Manufacturers: Josam, Smith, Wade or Zurn equal to number listed in cleanout and drain schedule.

2.9 TRAPS

A. Same material as pipe or fittings unless specified with fixtures. Refer to Section 22 4000 - Plumbing Fixtures. Provide 17 ga brass, chrome plated traps for exposed traps.

2.10 ELEVATOR SUMP PUMPS

A. Acceptable manufacturers: Aurora/Hydromatic, Weil

B. Pump shall be submersible type constructed of epoxy coated cast iron shell, cast iron volute, two vane enclosed semi-open recessed cortex non-clog bronze impeller, stainless steel shaft, stainless steel fasteners, upper sleeve and lover ball bearing factory sealed grease lubricated, and ceramic mechanical seal.

C. Pump shall be hermetically sealed, capacitor start, built-in thermal overload protection sized for no-overloading entire pump curve.

D. Pump shall be of capacity and electrical service as indicated in the equipment schedules on the drawings.

E. Pump controls shall include:
   1. Single on/off UL listed float switch

F. Pump accessories shall include:
   1. Discharge check valve
   2. Full port ball valve
   3. Union for each pump

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Install pipe and fittings in accordance with reference standards, manufacturer's recommendations and recognized industry practices.

B. Connect piping to fixtures, each piece of equipment, and drains. Install required piping as shown on drawings.

C. Grade horizontal lines with minimum of 1/8" per ft, except piping 2" diameter or smaller which shall be run at 1/4" per ft slope.

D. Install piping parallel with building lines and at heights, which do not obstruct any portion of window, doorway, stairway, or passageway, except, as may be shown on plans. Install overhead piping as high as possible.

E. Grade vent pipe for complete drainage by gravity to soil or waste pipes. Vent terminations shall be set true and level. Locate vent piping at least 10 ft away from window, door or intake openings. Coordinate closely with roofing contractor to prevent damage to roofing membrane. Flashing shall be in accordance with requirements of roofing manufacturer.

F. Where interferences develop, offset or reroute piping as required to clear interferences. Coordinate locations of plumbing piping with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances. Consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

G. Provide protective sleeve covering of elastomeric pipe insulation, where piping and/or fittings are embedded in masonry or concrete.

H. Maintain piping in clean condition internally during construction.

I. Mitered ells, notched tees, and orange peel reducers are not allowed. Bushings are not allowed on threaded piping.

J. Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including required service space for this equipment, unless piping is serving this equipment.

K. Set cleanouts true and level and protect properly throughout construction.

L. Set floor drains true and level and protect properly throughout construction. Weep holes shall be filled with removable material and kept free from concrete and other debris during construction. Weep holes shall be cleaned out for final working order. Provide safing for floor drains installed in elevated slabs.

M. Trap each fixture and piece of equipment requiring sanitary drainage connections. Trap seals shall be standard depth, except when deep seals are required by code. Traps shall be set true and level and located within limits of code requirements. Traps shall not be used as separator, interceptor or other type of device to retain solids. Traps shall be provided with thread type approved cleanout plugs when specified. Protect traps during construction and seal off to prevent stones, debris and other foreign matter from entering before use. Locate running traps for full accessibility with double cleanout.

N. Provide plugs or caps for pipe openings during construction to prevent debris from entering pipe. Temporary plug shall be plastic cap or equivalent.

3.2 UNDERGROUND WARNING TAPE

A. Provide warning tape for exterior buried sewers per Section 20 0553.

3.3 CAST IRON PIPE

A. No-hub Piping: Place gasket on end of one pipe of fitting and clamp assembly on end of other pipe or fitting. Firmly seat pipe or fittings ends against integrally molded shoulder inside neoprene gasket. Slide clamp assembly into position over gasket. Tighten fasteners to manufacturer's recommended torque.

B. Hub and Spigot Piping: Clean pipe end, bell, gasket seat and gasket of dirt or debris. Coat end of pipe and gasket with gasket lubricant. Insure pipe is supported off ground so lubricant does not pick up dirt. Push spigot end into end of gasket bell with levered pipe joining tool recommended by pipe manufacturer. Large diameter exterior mains may be joined by pushing end of pipe section with backhoe against wood blocking over pipe end. Insert to fully seated position or to reference mark on pipe.

C. Install cast iron pipe and fittings as recommended by CISPI in their publication "Installation of Cast Iron Soil Pipe and Fittings".

D. Support piping at every coupling. Locate hanger within 18" of coupling.

E. Installations with multiple joints within a 4 ft developed length shall be supported at every second joint.

F. Secure base of risers with thrust restraints to prevent joint separation. Restraint shall be in accordance with CISPI recommendations.

G. Brace horizontal piping 5" and larger to prevent horizontal movement. Install bracing at every branch connection and every change of direction in accordance with CISPI recommendations.

3.4 TESTING

A. Refer to Testing paragraph of Section 20 0000 - General Mechanical Requirements.

B. Water test may be applied to system either in its entirety or in sections. Piping shall be tightly plugged and submitted to 10 ft head of water located at highest point. Provide separate standpipe above highest point being tested or extend system to obtain required 10 ft head of water. Head shall be maintained for at least 30 minutes before inspection starts.

C. Defective work or material shall be replaced or repaired as necessary and inspection and test repeated. Repairs shall be made with new materials. No caulking of threaded joints or holes will be allowed.

D. Do not backfill pipe until successfully tested.

E. Testing with air will not be allowed.

End of Section

SECTION 22 16 00

NATURAL GAS PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies natural gas piping and accessories to 5 ft outside building wall.

1.2 RELATED WORK

A. Section 20 05 20 - Excavation and Backfill

B. Section 20 05 29 - Mechanical Supporting Devices

C. Section 20 05 53 - Mechanical Systems Identification

D. Division 26 - Electrical

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.4 QUALITY ASSURANCE

A. Order piping with each length marked with manufacturer's name or trademark and type of pipe; with each shipping unit marked with purchase order number, metal or alloy designation, temper, size, and supplier's name.

B. Installed material not meeting specification requirements must be replaced with material that meets these Specifications without additional cost to Laboratory.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Promptly inspect shipments to insure material is undamaged and complies with specifications.

B. Cover pipe to prevent corrosion or deterioration while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends from damage. End caps shall remain in place. Protect fittings, flanges, and unions by storage inside or by durable, waterproof, above ground packaging.

C. Off-site storage agreements will not relieve Contractor from using proper storage techniques.

D. Storage and protection methods must allow inspection to verify products.

1.6 SUBMITTALS

A. Manufacturer's technical data for the following:
   1. Pipe and fittings
   2. Joints
   3. Valves
   4. Regulators
   5. Appliance connectors

B. Shop Drawings on items specified herein.

C. Where loads imposed exceed design superimposed dead loads or suspended loads specified in contract documents, submit for approval to Structural Engineer of Record loads imposed on the primary structural frame. Submittal shall include location, magnitude and direction of imposed loads (basic, unfactored and direction of imposed loads (basic, unfactored load cases), graphically represented in their appropriate locations on a copy of the Contract Document structural framing plans or elevations as appropriate. Detail references indicating the connections applicable at each location shall be noted on the submittal drawings.

1.7 NATURAL GAS SERVICE

A. Include in Bid cost of gas service to building, including pressure reducing valves, if required, and gas meter.

B. All charges for gas service as shown on drawings including connection from main in street or other location to gas meter shall be paid by this Contractor. This includes setting of gas meter.

C. Gas service, meters and regulating equipment will be installed by contractor on inlet side of meters.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials herein specified shall be new, unless otherwise noted.

2.2 BELOW GROUND PIPE, FITTINGS AND JOINTS

A. Service Entrance Pipe:
1. Same as above ground covered with flexible polymer film with coal tar and synthetic elastomeric coating of 36 mil thickness or extruded high density polyethylene factory applied coating of 30 mil thickness. Wrap fittings with 10 mil polyethylene tape, ANSI A21.5, double layer, half-lapped. Minimum dielectric strength exceeding 12 kV. Use compatible primer below polymer film or polyethylene tape.

2.3 ABOVE GROUND PIPE, FITTINGS AND JOINTS (UNDER 1 PSIG)

A. 2" and Smaller:
1. Pipe: ASTM A53, Type F, Schedule 40, carbon steel
2. Fittings: ASTM A197/ANSI B16.3 Class 150, black malleable iron, threaded
3. Joints: Threaded

B. 2-1/2" and Larger:
1. Pipe: ASTM A53, Grade B, Type E or S, Schedule 40, carbon steel
2. Fittings: ASTM A234 Grade WPB/ANSI B16.9, Schedule 40, seamless, carbon steel, welded
3. Joints: Welded

2.4 UNIONS

A. Steel Pipe, 2" and Smaller:
1. Malleable iron, ground brass seat, 150 psi steam working pressure; Stockham Figure 694 or equivalent
2. Forged steel, spiral wound gasket seats, ASTM A105, ANSI B16.5

B. Steel Pipe, 2-1/2" and Larger:

1. ANSI 150 lb class forged steel flanges, ASTM A105/ANSI B16.5. Standard bolt pattern, ANSI 150 lb class 1/8" thick gasket, Type 304 stainless steel, spiral wound metal with graphite filler.

2.5 VALVES

A. Ball Valves:

1. Acceptable Manufacturers: Neles-Jamesbury, Apollo, Kerotest, Nibco and Watts equal to manufacturer's Figure number listed
2. 2" and Smaller:
   a. Bronze body, threaded, quarter turn, chrome plated brass ball, large port, reinforced TFE seat and stem packing, blowout-proof stem, 250 psig LP-Gas, UL Listed. Apollo 80-100 Series.
3. 2-1/2" through 8":
   a. Carbon steel body, ASTM A53 Grade A, Class 150, quarter turn, carbon steel weld ends, ASTM A572 Grade 50 and ANSI B16.25, Type 304 stainless steel ball, stainless steel stem, Buna-N double O-ring seals, PTFE seats, ductile iron hand wheel, API-6D test requirement. Kerotest Weldball.

B. Gas Pressure Regulators:

1. Acceptable Manufacturers: Fisher, Rockwell or American meeting capacity and performance listed
2. 2" and Smaller: Cast iron body, aluminum spring case, plated steel spring, Nitrile diaphragm and disc, threaded, vent to exterior of building, 150 psi CWP, -20°F to 160°F , Fisher Type S100K, S200 or S300.

2.6 METERS

A. Manufacturers: American Meter, Sensus or Laboratory and engineer approved equal.

B. Diaphragm Meter

1. One piece cast aluminum alloy body, aluminum alloy top and covers, molded diaphragms, adjustable tangents, self-lubricated bearings, acrylic finish coat.
2. Provide pulse output for BAS monitoring
3. Meter shall have a nominal capacity of 650 scfh at 10 psig inlet pressure.

C. Regulators

1. Cast aluminum body, lever type, spring loaded, internal relief.

2.7 APPLIANCE CONNECTORS

A. Appliance connectors shall be corrugated brass tubing with protective exterior coating, brass valve with non-displaceable rotor, brass outlet fitting, and AGA certified. Connector length shall be as required to allow servicing of appliance. Inside diameter of connector shall be 3/8" for appliances up to 60,500 Btu per hr 1/2" for appliances up to 106,000 Btu per hr. Connectors shall be Brass-Craft "Super Armoplast" SD4L Series or SC4E Series.

2.8 CASEWORK FLEXIBLE GAS PIPING

A. 2” and Smaller:

1. Tubing: Flexible gas piping shall be UL Listed, FM approved, 300 series corrugated stainless steel tubing (CSST) fabricated in accordance with ASTM A240 and conforming to ANSI/CSA LC-1. Tubing shall be suitable for operation with natural gas or LP (propane) gas.

2. Fittings and Joints: Yellow brass mechanical fittings and joints with stainless steel AutoFlare pilot insert for ID tubing
3. Jacket: Fire retarded, UV resistant, extruded polyethylene with ASTM E-84 flame and smoke density rating of 25/50

B. Manufacturer: Omagaflex TracPipe or equal

PART 3 - EXECUTION

3.1 GENERAL

A. Install gas piping according to requirements of this Section, local gas utility, NFPA 54 National Fuel Gas Code, AGA pamphlets and as shown on drawings.

B. Piping through roof to be run through approved roof penetration with flashing and counter flashing.

C. Install buried/underground polyethylene gas piping with trace wire taped to pipe along its entire route. Secure wire to pipe to prevent movement during backfilling. Extend trace wire to valve boxes and service entrance.

D. Install underground polyethylene gas piping exterior to building according to pipe manufacturer's recommendations and to meet local gas utility company's installation standards.

E. Grounding to gas piping is prohibited.

F. Gas piping shall be installed with dirt legs adjacent to equipment and with drain tees and plugs at low points.

G. Gas piping in plenum ceilings is prohibited.

H. Install gas piping above ground in buildings. Gas piping shall not be installed below building floor or footings.

I. Pitch horizontal piping downward at 1" per 60 ft in direction of flow toward risers or appliances. Install minimum of 4" deep dirt leg at bottom of each vertical run and at each appliance. When installing mains and branches, cap gastight each tee or pipe end, which will not be immediately extended. Take branch connections to main from top or side of main.

J. Coat underground piping with corrosion resistant tape equal to Tapecoat H-30 and cathodically protected as specified herein. Repair breaks in tape coating caused by installation process.

K. Make threaded joints by cutting pipe square and reaming inside. Threads shall be cut so exposed threads do not exceed 3 in number. Protect exposed threads against corrosion. Use only joint compounds approved for gas piping.

L. Do not exceed maximum torque (inch-pounds) specified by valve Manufacturer during installation of seismic shut-off valve.

M. Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless piping is serving this equipment.

3.2 UNDERGROUND WARNING TAPE

A. Provide warning tape for exterior buried gas lines per Section 20 0553.

3.3 PRESSURE REGULATORS

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

B. Regulator shall be accessible for maintenance and protected from fire and mechanical damage. Regulator shall be supported from structure by brackets and supports.

C. Vent from relief valve shall be routed to outside. Terminate vent with protection screen and return bend. If above ground vent terminates in area subject to snow accumulation, terminate line at least 5 ft above grade. Coordinate vent routing with other trades to point of termination. Size vents in accordance with regulator manufacturer's requirements for regulator flow rate and length of run.

D. Provide unions on both sides of regulators for removal and maintenance.

E. Provide gas cock for pressure verification.

3.4 CONNECTIONS

A. Provide appliance connectors at ranges, ovens and other appliances, which require that they be relocated before accessing gas connection. Do not use appliance connectors for water heaters or for other equipment or appliances, which do not require that they be relocated before accessing gas connection.

B. Install shut off valve at each appliance. Provide valved connection at main for equipment and appliances furnished by others.

C. Shutoff valves shall be accessible in case of emergency; installed minimum of 5 ft from equipment. Provide shutoff valves at each piece of equipment.

3.5 WELDER QUALIFICATIONS

A. Welding procedures, welders, and welding operators for building service piping to be in accordance with certified welding procedures of National Certified Pipe Welding Bureau and Section 927.5 of ASME B31.9 Building Services Piping or AWS 10.9 Qualification of Welding Procedures and Welders for Piping and Tubing.

B. Before metallic welding is performed, submit Welding Procedure Specification together with Procedure Qualification Record as required by Section 927.6 of ASME B31.9 Building Services Piping.

C. Before welding is performed, submit Standard Welding Procedure Specification together with Procedure Qualification Record as required by Section IX of ASME Boiler and Pressure Vessel Code.

D. Welded joints shall be made in conformance with latest provision of Code for Pressure Piping, ANSI Standard B31-8 - Gas Transmission and Distribution Systems. Welds to be made by qualified welders experienced in piping work. Welding, piping fabrication, etc. shall be in accordance with ASME Code, State Codes, and Welding Manual of Mechanical Contractors Association of America.

E. Architect or Engineer reserves right to test work of welder employed on Project, at Contractor's/Laboratory's expense. If work of welder is found to be unsatisfactory, welder shall be prevented from doing further welding on project and defective welds replaced at no additional cost to Laboratory.

3.6 TESTING

A. Test above ground steel gas piping with dry compressed air at 50 psi for 2 h. Soap test of each joint shall be done to detect leaks during 2 h period. No loss of pressure allowed during test period. No piping shall be concealed until successfully tested.

B. Test underground polyethylene gas piping at 100 psi with dry air for 2 h. No loss in pressure allowed. Defective joints shall be cut out, pipe repaired, and retested. No piping may be backfilled until successfully tested.

C. Types and extent of non-destructive examinations required for pipe welds are as shown in Table 136.4 of ASME Code for Pressure Piping, ANSI/ASME B31.1 - Power Piping. If requirements for non-destructive examination are to be other than that stated above, degree of examination, and basis for rejection shall be matter of prior written agreement between fabricator, or Contractor and purchaser.

D. Local regulating and governing agencies may require periodic testing of seismic valve's ability to shut-off gas flow during seismic event. Follow procedures specified by local governing agency for test.

3.7 CLEANING

A. Before actuation of gas system, flush system with dry nitrogen to ensure clean system free of oil and construction debris.

End of Section

SECTION 22 21 14

PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section covers material specialties for piping systems.

1.2 RELATED WORK

A. Section 22 05 94 - Domestic Water Systems Balance

B. Section 22 11 18 - Water Distribution System

C. Section 22 13 14 - Sanitary Waste and Storm Drainage Systems

D. Section 22 61 14 - Laboratory Compressed Air System

E. Section 22 62 14 - Laboratory Vacuum Piping System

F. Section 22 66 53 - Corrosion Resistant Waste and Vent System

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.4 SUBMITTALS

A. Manufacturer's technical data for the following:
   1. Thermometers
   2. Pressure gauges
   3. Pressure reducing valves
   4. Pressure relief valves
   5. Strainers
   6. Backflow preventers
   7. Flexible connections
   8. Air vents
   9. Trap primers
   10. In-line check valves
   11. Flashings
   12. Safings

B. Shop drawings on items specified herein.

C. Certificates: Submit performance testing certificates for reduced pressure backflow preventers and double check backflow preventers.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials herein specified shall be new unless otherwise noted.

2.2 THERMOMETERS

A. Manufacturers: Miljoco, Taylor, Trerice, Weksler and Weiss equal to Trerice number listed

B. Thermometers shall be 9" die cast aluminum case and frame, double strength glass window, adjustable angle stem, permanently stabilized glass tube with mercury free indicating fluid, readable scale with gradations from 30 to 240°F. Provide brass extension neck sockets of appropriate length. Trerice Series No. A400 (old catalog number BX91400).

2.3 THERMOMETER SOCKETS AND TEST WELLS

A. Brass construction with threaded connections suitable for thermometer bulbs and control sensing devices, well length suitable for pipe diameter with extended neck as required to suit pipe insulation. Trerice 5550 Series.

B. Test wells for stainless steel piping shall be same material as piping.

2.4 PRESSURE GAUGES

A. Manufacturers: Ashcroft, Marsh, Marshalltown, Miljoco, Taylor, Trerice, U.S. Gauge, Weiss, and Winters, equal to Trerice number listed

B. Pressure gauge shall be 4-1/2" die cast aluminum case, double strength glass window, readable dial scale with gradations from 0 to 200 psi, phosphor bronze bourdon tube, brass socket. Provide shutoff valve with pressure gauge, Trerice Series No. 600. Provide with No. 301 Series maximum registering pointer.

C. Gauge accuracy shall meet ANSI B40.1 Grade 1A (1% full scale).

D. Pressure gauges shall be calibrated for the following pressure ranges:
   1. Domestic Water: 0 to 160 psi at 2 psi increments
   2. Laboratory Air: 0 to 100 psi at 1 psi increments
   3. Carbon Dioxide: 0 to 100 psi at 1 psi increments
   4. Laboratory Vacuum: 30" Hg at 0.2" Hg increments

E. Pressure Snubbers:
   1. 1/4” or 1/2” size, matching gauge size, 1000 psig WP. Brass for copper or carbon steel pipe, stainless steel for stainless steel pipe.

2.5 PRESSURE RELIEF VALVE

A. Manufacturers: Cash-Acme, Consolidated, Kunkle, Lonergan, and Watts

B. Bronze body, resilient seat/seal, ASME Section VIII, stainless steel spring

C. Refer to Schedules on drawings for performance requirements.

2.6 STRAINERS

A. Manufacturers: Conbraco, Hoffman, Keckley, Metraflex, Mueller, or Wheatley

B. Strainers shall be comparable to regulator or control valve specified. Strainers shall be "Y" type for liquid service to 400 lbs WOG at 210°F, with 40 mesh stainless steel screen. Body material shall be compatible with installed piping, stainless steel, or FDA approved, heat fused, epoxy coated interior.

2.7 BACKFLOW PREVENTER

A. Reduced Pressure Zone Backflow Preventers:
   1. Manufacturers: Cla-Val, Febco, Apollo or Watts, equal to model listed
   2. 3/4" through 2": Bronze body, resilient check valve seats, shut-off valves, Y-pattern strainer with bronze body and stainless steel screen, drain line air-gap fitting, bronze test cocks, certified in accordance with ASSE 1013 and AWWA C511, equal to Watts number 919-S
   3. 2-1/2" through 10": Cast iron body, bronze trimmed check valves, shut-off valves, Y-pattern strainer with cast iron body and stainless steel screen, drain air-gap fitting, bronze test cocks, certified in accordance with ASSE 1013 and AWWA C511, equal to Watts number 957-S

2.8 TRAP PRIMERS

A. Manufacturers: Precision Plumbing Products, Portland, OR.

B. TP-1: Trap primer body shall be of machined brass with air inlet ports and backflow valve. Trap primer shall be activated by water pressure variation of 5 psi or greater to deliver metered amounts of water. Model PR-500.
   1. Distribution units shall be patented containers with 1 to 4 tube outlets. Two outlets maximum with model P-2, 3 to 4 outlets with model P-1.

C. TP-2: Bronze body with atmospheric-vented drain chamber. 125 psig minimum working pressure. Outlet manifold with number of connections as indicated on drawings. Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.
   1. Solenoid valve on inlet to be controlled by local timer. Timer to operate on 120 V power supply.
   2. Precision Plumbing Products – Model MP-500-115V.

2.9 IN-LINE TRAP SEALER

A. Manufacturers: Sure Seal, Trap Guard by Proset

B. Inline trap sealer shall be ABS plastic housing and neoprene rubber diaphragm or Elastomeric PVC material with curl closure at bottom.

2.10 IN-LINE CHECK VALVES

A. Manufacturers: Circle Seal Control - Anaheim, CA., Durabla Manufacturing Co. - Paoli, PA, Apollo Division - Conbraco Industries, Inc. - Matthews, NC.

B. Bronze or bronze/stainless steel construction with spring loaded check (316 stainless steel spring) and straight through flow. Apollo Ball-Cone model 62-100 Series, or approved equal.

2.11 FLEXIBLE CONNECTIONS

A. Bronze, braided flexible hose or neoprene twinsphere connectors by Mason Industries with 150 psi WOG working pressure rating.

B. Alternate manufacturers are Redflex, Resistoflex and Flexonics.

2.12 AIR VENTS

A. Manual Air Vents: Bell and Gossett Model 4V, 125 psi pressure at 210°F temperature, or approved equal. Use 1/2" ball valve for main pipes.

2.13 FLASHINGS

A. Elastomer Membrane Roofing:
   1. Pipe clamps, Fernco Series 1056 flex coupling with Series 300 stainless steel clamps.

B. Built-Up Roofing:
   1. 4 lb sheet lead, to 18" beyond drain perimeter.
   2. Preformed lead vent collar, 4 lb sheet lead, to 18" beyond vent perimeter; 18" minimum square base flange.
   3. Nobleflex roof drain flashing of Chloraloy and 20 lb asphalt saturated roofing felt bonded together.

2.14 SAFINGS

A. 4 lb sheet lead, to 18" beyond edge of drain on all sides.

B. Chlorinated polyethylene (CPE) as manufactured by Noble Company under trade name Chloraloy 240.

C. Polyvinyl Chloride (PVC) shower pan line, 40 mil thickness, ASTM D4551.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide thermometers where indicated on drawings. Thermometers shall be easily read from floor or maintenance platforms. Calibrate thermometers to insure accuracy.

B. Install pressure gauges where indicated on drawings. Gauges shall be easily read from floor or maintenance platforms. Provide extensions as required to make gauges easily readable. Calibrate gauges to insure accuracy.

C. Install backflow preventers as indicated on drawings. Flush debris from strainers. Certified tester shall test reduced pressure zone backflow preventers to verify that functions are operational. Route vent line to adjacent hub drain.

D. Install strainers for equipment including pumps, meters, backflow preventers, reducers and regulators, and as shown on drawings.

E. Install trap primer units as recommended by manufacturer and as indicated for priming drain traps. Insure positive air gap to protect against backflow.

F. Install in-line check valves where specified or as indicated on drawings.

G. Install flexible connections for base mounted pumps and other vibrating equipment.

H. Install air vents at high points in water systems where air may collect.

I. Safing:

1. Install safing for floor drains. Extend safing to 18" from edge of drain. Safing shall be clamped to floor drain body and pitched to drain to weep holes. Floor drains installed in unexcavated areas do not require safing.
2. Where core drilled floor drain installation into existing floor slab has been approved by A/E, drain strainer inlet shall be grouted in place with non-shrink epoxy concrete approved by Structural Engineer.
3. Install safings for showers. Concrete floor shall be smooth and free of dirt. Seal joints per manufacturer's recommendations and turn up sides minimum of 6" above curb or maximum water level. Safing shall clamp into drip pan of floor drain and be secured by flashing clamp to assure drainage into weep holes of drain body. Inside vertical corners of showers shall have 12" strips 6 ft above floor, extend 6" in each direction and bottom to overlap pan 3".
4. Membrane roofing material, preformed elastomer pipe pots, and flashing seams are provided by Roofing Contractor for pipe penetrations and drain flashing. Plumbing Contractor shall provide drain flashing clamps and stainless steel strap clamps for piping penetrations. Coordinate with General Contractor to facilitate sealing drain flashing and pipe penetrations.

J. Flashing:

1. Coordinate flashings on roof closely with Roofing Contractor. Install flashings as required to insure proper vapor barrier and as directed by Architect.
2. Install flashing for vents through roof, roof and overflow drains, and area drains. Flashing shall extend minimum of 18" from center of pipe. Flashing shall turn into pipe in neat workmanlike manner. Install 1" insulation between outside of pipe and flashing.
3. Install flashing for roof drains and area drains. Flashing shall extend minimum of 18" beyond edge of drain and shall be clamped into drain body.
4. Use premolded flashing assembly for roof penetration of medical air intake piping. Install 1" of insulation between flashing and outside of pipe.
5. Use premolded flashing assembly with hood for roof penetrations of medical vacuum exhaust piping. Set bottom of hood at 24" above finished roof.
6. Roof penetrations for corrosive or acid vent systems shall be preformed EPDM vent pot with flex coupling pipe clamp collar.

3.2 TESTING

A. Safings shall be subject to standing water test to detect leaks and proper drainage to weep holes of floor drain.

End of Section

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SECTION 22 31 00

WATER CONDITIONING EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section lists equipment to be used to condition domestic water systems.

1.2 RELATED WORK

A. Section 20 07 00 - Mechanical Systems Insulation

B. Section 22 21 14 - Material Specialties

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.4 SUBMITTALS

A. Shop drawings on items specified herein.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Culligan, Hellenbrand, U.S. Filter

2.2 SOFTENER

A. Description: Duplex, twin alternating, water softener shall include two fiberglass vessels with internal distributors, piping, fully automatic brass multi-port control valves, alternating controller, pressure gauges, sample valves, resin, gravel, outlet "Y" strainer, structural base, dry-brine maker and brine eductor. Unit shall be preassembled, prewired, and hydrostatically tested. Media shall be packaged separately.

B. Design Conditions:

1. Design flow:	Refer to equipment schedule
2. Pressure:	30-80 psig
3. Temperature:	50°F to 80°F

C. Design Criteria:

1. Volumetric Flow Rate:	less than 15 gpm/ft^3 at design flow rate
2. Backwash Flow Rate:	greater than 1.2 gpm/ft^3
3. Maximum Hardness Leakage:	5 ppm (less than)
4. Normal Hardness Leakage:	0 ppm

D. Resin:

1. Type:	Gel - strong acid cation
2. Ionic Form	Sodium
3. Regenerant Chemical:	NaCl saturated

4. Regenerant Quantity: 15 gpm/ft^3 maximum
5. Method of Chemical Introduction: Eductor
6. Capacity/ft^3 (est.): 30,000 grains (as $CaCO_3$) at max salt dosage

E. Mechanical:
1. Softener vessel:
   a. Material: Fiberglass or epoxy coated carbon steel
   b. Pressure Rating: 100 psig/150 psig
   c. Temperature Rating: 120°F
   d. Piping Connections: threaded
   e. Warranty: two years against interior, exterior and lining defects.
   f. Upper distributor: Single point baffle type, schedule 40 galvanized
   g. Lower distributor: hub and radial arm type, PVC or ABS
2. Strainer: Bronze or PVC body with 20 mesh screen

F. Brine tank:
1. Quantity: one
2. Material: Polyethylene
3. Salt Dose: 6-15 lb/ft^3

G. Electrical
1. Controls: Motor-driven control valve shall stage each softener through regeneration steps. Regeneration shall be initiated by a signal from alternator controller. Regeneration frequency shall be based on throughput volume, totalized at common effluent of both softeners.
2. 120vac, 1ph, 60 HZ power supply

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install water conditioning equipment level in location as shown on drawings. Support pipe to and from equipment from building structure; do not support piping from equipment.

B. Follow installation instructions of equipment manufacturer. Installation instructions shall always be at site.

C. Provide start up service by manufacturer or authorized representative.

D. Fill salt storage/brine tank after successful test results.

3.2 TEST

A. Operate equipment through regeneration cycle. Verify proper cycle time and brine injection.

B. After satisfactory performance of sequence of operation, take water samples of raw and conditioned water and send to lab to verify performance of the equipment.

3.3 BALANCING

A. Adjust equipment to work with minimum dosage of brine.

End of Section

SECTION 22 33 14

WATER HEATING EQUIPMENT

PART 1 - GENERAL

1.1 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions of Contract, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.2 QUALITY ASSURANCE

A. Water heating equipment shall conform to State and Local Codes, meet national standards, and be certified by respective organization and bear its stamp.

1.3 SUBMITTALS

A. Shop drawings on items specified herein.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials specified herein shall be new unless otherwise noted.

2.2 ATMOSPHERIC GAS FIRED TANK TYPE WATER HEATER

A. Manufacturers: Bock, Bradford White, Lochinvar, Rheem, Ruud, State

B. Water heater shall be high efficiency atmospheric gas fired water heater. Water heater design shall bear “CSA Design Certified” mark, have 5 yr tank warranty and have 1 yr parts warranty.

C. Burner shall be cast iron or stainless steel with thermostat adjustment of 90 to 180°F. Controls shall be arranged for emergency shut off in event of pilot failure.

D. Tank shall be glass lined steel ASME rated for 150 psig. Tank shall have removable magnesium anode rod, pressure and temperature relief valve, drain valve, boiler-type hand-hole cleanout, draft hood, polyurethane insulation, painted steel jacket, inlet and outlet thermometers, and gas pressure regulator set for operation at 14" WG natural gas.

E. Refer to Water Heater Schedule for water heater capacity required.

2.3 ELECTRIC TANK TYPE WATER HEATER

A. Manufacturers: Bock, Rheem, Ruud, State.

B. Water heater shall be electric water heater. Water heater design shall bear “CSA Design Certified” mark, have 3-year tank warranty and have 1-year parts warranty.

C. Element(s) shall be zinc-plated copper sheath with thermostat adjustment of 90 to 180°F. Controls shall be arranged for emergency shut off in event of pilot failure.

D. Tank shall be glass lined steel rated for 150 psig. Tank shall have removable magnesium anode rod, pressure and temperature relief valve, drain valve, boiler-type hand-hole cleanout, polyurethane insulation, painted steel jacket.

E. Refer to Water Heater Schedule for water heater capacity required.

2.4 THERMAL EXPANSION TANK

A. Manufacturers: Amtrol, Goulds, Wessels

B. Expansion tank shall be precharged, diaphragm-type tank designed for hot water systems. Tank shall be ASME rated for 125 psig and come with replaceable rubber bladder, air charge fitting, steel base ring stand (floor mounted tanks only), factory primed and enamel painted exterior, and ASME relief valve. Materials exposed to water to be NSF or FDA approved for potable water service.

C. Basis of design as listed in schedule, precharged at 40 psig.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install water heaters as recommended by manufacturer. Provide final connections as required. Coordinate water heater location with other Contractors.

B. Initial start up and balancing service shall be provided by representative of manufacturer.

C. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

SECTION 22 40 00

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section lists plumbing fixtures and accessories including method of installation.

1.2 RELATED WORK

A. Section 22 11 18 - Water Distribution System

B. Section 22 13 14 - Sanitary Waste and Storm Drainage Systems

C. Section 22 16 00 - Natural Gas Piping

D. Section 22 61 14 - Laboratory Compressed Air System

E. Section 22 62 14 - Laboratory Vacuum Piping System

F. Section 22 63 14 - Nitrogen, Carbon Dioxide, and Specialty Gas Piping Systems

G. Section 22 66 53 - Corrosion Resistant Waste and Vent System

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.4 SUBMITTALS

A. One package of manufacturer's technical data for all items. Submittal shall be assembled brochure, showing cuts and full detailed descriptions for each item.

B. Shop drawings on items specified herein.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Vitreous china fixtures shall be of highest quality, non-absorbent, hard-burned, and vitrified throughout.

B. Enameled ware shall be quality cast iron of uniform thickness and density, glazed to uniform depth and high gloss rubbed smooth, without chips or flaws, craze, or cracks, and completely acid resisting.

C. Stainless steel fixtures shall be 302/304 types of non-corrosive steel, 18 ga self rim for cabinet sinks, 14 ga for free standing compartment type sinks. Sink material shall have satin finish and cover corners, with faucet holes punched to match specified faucet fitting.

D. Precast receptors and shower basins shall be "terrazzo" concrete. Receptor and basin colors shall be standard colors unless otherwise noted. Assembly of drain to waste piping shall be made from floor level on which basin or receptor is installed.

E. Insulation for traps and supplies shall be molded closed cell vinyl insulation and shall meet ASTM E84 for flame and smoke spread. Insulation shall be vandal resistant and be color as listed.

2.2 MANUFACTURERS

A. Water closets, urinals, and lavatories: American Standard, Eljer, Kohler, or Zurn equal to number listed.

B. Water Closet Seats: Bemis, Beneke, Centoco, Olsonite or Zurn equal to number listed.

C. Flush Valves: Delaney, Sloan, TOTO, or Zurn equal to number listed.

D. Stainless Steel Sinks: Advance Tabco, Elkay or Just equal to number listed.

E. Electric Water Coolers: Elkay, Halsey-Taylor, Haws, Oasis, or Sunroc equal to model listed.

F. Service Sinks: American Standard, Eljer, or Kohler equal to number listed.

G. Mop Basins (Janitor Sinks): Fiat, Mustee, Stern-Williams, or Zurn equal to number listed.

H. Emergency Eyewashes and Showers: Bradley, Encon, Guardian, Haws, or Speakman, equal to number listed.

I. Manual Faucets: Chicago Faucet, T and S Brass, or Zurn equal to number listed.

J. Sensor Activated Faucets: Chicago Faucet, Kohler, Sloan, TOTO, or Zurn equal to model listed.

K. Fixture Traps: Engineered Brass Company, Kohler, McGuire, or Zurn equal to number listed.

L. Insulated Traps and Supplies: McGuire, Plumberex or True-Bro equal to model listed.

M. Supplies and Stops: Chicago Faucet , Kohler, McGuire or equal to number listed.

N. Shower Valves and Mixing Valves: Leonard, Powers, or Symmons equal to number listed.

2.3 CARRIERS AND SUPPORTS

A. Carrier manufacturers shall be Josam, J.R. Smith, Wade, or Zurn, as outlined herein, with models suitable to fixture and use intended. Provide carriers with adjustable faceplate, rectangular steel uprights and at least 3 bolt lugs for securing carrier to floor. Adjustable water closet carriers shall be either right or left, single or double, horizontal or vertical as suggested by drawings and riser diagrams.

2.4 WATER CLOSETS

A. WC-1 Water Closet (wall hung)
   1. Fixture: Kohler "Kingston" Model #K-4330or, white vitreous china, wall hung siphon jet, elongated bowl, 1.28 gallons per flush, 1-1/2" top inlet spud.
   2. Fixture Fittings and Accessories: Gaskets-wax, bolts with chromium plated caps, nuts, and washers.
   3. Flush Valve: Sloan ECOS Model CF 8111(*), exposed battery operated flushometer, top stud connection, 1.28 gal per flush, with courtesy flush. 1.28 gallons per flush.
   4. Seat: Bemis #1955-SS/C, heavy duty, elongated bowl, open front, plastic seat, less cover, white color, with stainless steel self-sustaining check hinge.
   5. Carrier: J.R. Smith series 200 adjustable face plate, rear support for single carries.

B. WC-2 Water Closet (wall-hung, barrier-free)
   1. Same fixture and fittings as WC-1.

2. Provide carrier support for barrier free mounting height of minimum 17" to top of bowl from finished floor.

2.5 URINALS

A. UR-1 Urinal (wall-hung)
   1. Fixture: Sloan WEUS-1000.1401-0.13 ECOS, vitreous china, wall mounted washout type, rim extended to 14-1/4" from wall, 3/4" top inlet spud.
   2. Fixture Fittings and Accessories: Gaskets-wax, bolts with chromium plated caps, nuts, and washers.
   3. Flush Valve: Sloan WEUS-1000.1401-0.13 ECOS, sensor operated, battery powered flushometer, 3/4" top spud connection, 0.125 gallon per flush.
   4. Carrier : J.R. Smith 0637 rectangular uprights, bearing plate.

B. UR-2 (wall hung, barrier-free)
   1. Same fixture and fittings as UR-1.
   2. Provide carrier support for barrier-free mounting height of maximum 17” to top of rim from finished floor.

2.6 LAVATORIES

A. L-1 Lavatory (wall-hung, barrier Free)
   1. Fixture: Kohler "Greenwich" K-2032, 20" x 18", vitreous china, wall hung, drilled for carrier support, mount at 34" above finished floor to rim.
   2. Faucet: TOTO TEL3GG10#CP, polished chrome, gooseneck, self generated power or battery operated, sensor controlled, single supply, 0.5 gpm flow rate.
   3. Mixing Valve: Symmons 5-120, exposed mixing valve, lockable handle.
   4. In-line Check Valve: Brass or bronze body, stainless steel spring, Buna-N o-ring, straight through flow. Circle Seal 2200 Series or approved equal.
   5. Drain and Trap: McGuire Prowrap Model PW2125, WC pre-wrapped off-set grid drain, 1-1/4" tailpiece, 1-1/4" x 1-1/2" cast brass P-Trap with cleanout, 17 ga tubing outlet. Insulation kit for hot and cold water supply and stops included with kit.
   6. Stops and Supplies: Chicago Faucet 1017-CP angle pattern, lock shield cap, loose key handle, with copper alloy control valve bodies, stems, and gland nuts, 1/2" NPT inlet x 3/8" compression outlet.
   7. Traps, Stops and Supplies Insulation: Plumberex “Pro-Extreme” Series, offset strainer, p-trap and angle stop and supply cover, white.
   8. Carrier: Josam 17100/17105, J.R. Smith 700-M31, Zurn Z-1231, concealed arms, rectangular steel uprights.

B. L-2 Lavatory (undercounter mount)
   1. Fixture: TOTO LT569, vitreous china, undercounter mount, cotton (white)
   2. Faucet: TOTO TEL3GG10#CP, polished chrome, gooseneck, self generated power or battery operated, sensor controlled, single supply, 0.5 gpm flow rate.
   3. Mixing Valve: Symmons 5-120, exposed mixing valve, lockable handle.
   4. Drain: Chicago Faucet #327, P.O. perforated grate strainer, 1-1/4" tailpiece.
   5. Drain and Trap: McGuire Prowrap Model PW2125, WC pre-wrapped off-set grid drain, 1-1/4" tailpiece, 1-1/4" x 1-1/2" cast brass P-Trap with cleanout, 17 ga tubing outlet.
   6. Stops and Supplies: Chicago Faucet 1017-CP angle pattern, lock shield cap, loose key handle, with copper alloy control valve bodies, stems, and gland nuts, 1/2" NPT inlet x 3/8" compression outlet
   7. Traps, Stops and Supplies Insulation: Plumberex "Pro-Extreme" Series, offset strainer, p-trap and angle stop and supply cover, white.

2.7 SINKS

A. S-1 Sink (counter mounted, single bowl):
   1. Fixture: Elkay "Lustertone" #LR-2219, type 302 stainless steel, 18 ga, self rimming, single compartment, satin finish, fully undercoated, compartment dimensions 18" x 14" x 7.5" deep, 3 faucet holes.
   2. Faucet: Chicago Faucet #201-AGN8AE35-317CP, mixing valve faucet, 8" swing gooseneck, wrist blade handles, .05 gpm flow control, 8" faucet centers, cast or copper alloy construction with renewable or replaceable operating mechanisms, polished chrome finish.
   3. Drain: Elkay #LK-99 1-1/2" diameter drain with conical strainer basket, stainless steel construction.
   4. Trap: Kohler K-9000, 1-1/2" x 1-1/2" p-trap, cleanout plug, adjustable with connected elbow and nipple to wall, chrome plated.
   5. Stops and Supplies: Chicago Faucet #1006, angle pattern, lock shield cap, loose key handle, with copper alloy control valve bodies, stems, and gland nuts, 1/2" NPT inlet x 1/2" compression outlet.

B. S-2 Sink (wall mounted, single bowl):
   1. Fixture: Just A-33338-S, type 304 stainless steel, 18 ga, wall hung, single compartment, polished finish, fully undercoated, compartment dimensions 16" x 11.5" x 5" deep, 1 faucet holes.
   2. Faucet: Just JSL-100-B, sensor mixing valve faucet, 0.5 gpm flow control, single hole, cast or copper alloy construction with renewable or replaceable operating mechanisms, polished chrome finish.
   3. Drain: Elkay #LK-99 1-1/2" diameter drain with conical strainer basket, stainless steel construction.
   4. Trap: Kohler K-9000, 1-1/2" x 1-1/2" p-trap, cleanout plug, adjustable with connected elbow and nipple to wall, chrome plated.
   5. Stops and Supplies: Chicago Faucet #1006, angle pattern, lock shield cap, loose key handle, with copper alloy control valve bodies, stems, and gland nuts, 1/2" NPT inlet x 1/2" compression outlet.

2.8 SHOWERS

A. SH-1 Shower
   1. Floor and Enclosure by General Contractor.
   2. Valve: Powers Model #E427-E-K-1-0-7-0-W concealed thermostatic control valve with stops, complete with vinyl hose and hand/mounted shower head with wall rod mount, vacuum breaker, and 1.5 gpm flow control.
   3. In-line Check Valve: Brass or bronze body, stainless steel spring, Buna-N O-ring, straight through flow. Circle Seal 2200 Series or approved equal.

2.9 ELECTRIC WATER COOLERS/DRINKING FOUNTAINS

A. EWC-1 Electric Water Cooler (Barrier Free):
   1. Fixture: Oasis Model #M8CREE, high/low sensor water cooler with recessed condensing unit, replaceable carbon filter, stainless steel bowl, drain, wall panel, and with flow restricting bubbler.
   2. Trap: Kohler K-9000, 1-1/2” w/cleanout.
   3. Supply/Stop: Chicago Faucet #1006, angle pattern, lock shield cap, loose key handle, with copper alloy control valve bodies, stems, and gland nuts, 1/2" NPT inlet x 1/2" compression outlet.

2.10 JANITOR’S SINKS

A. JS-1 Janitor’s Sink:
   1. Fixture: Fiat #TSB-200 pre-cast terrazzo, 24" x 24" x 12" with integral stainless steel grid strainer outlet.

2. Faucet: Chicago Faucet 911-IS, cast or wrought copper alloy, combination faucet mounted 36" above finished floor. Spout shall have pail hook, 3/4" hose connection, top or bottom wall brace. Handles on faucets shall be cast, formed, or drop forged copper alloy. Escutcheons shall be either forged copper alloy or CRS. Valves shall include concealed integral stops, 8" centers. Elevated vacuum breaker mounted 7'-6" above finished floor. Exposed parts shall be polished chrome plated.
3. Trap: 3" p-trap to match piping system.
4. Accessories: Fiat #832-AA hose and hose bracket, 30" long, 5/8" rubber hose, and stainless steel hose bracket. Mount bracket at least 18" above finished floor and 6" left of faucet center. Fiat #MSG. Stainless steel wall guards on two walls, Type 304, 20 ga, and 12" high.

B. JS-2 Janitor's Sink:
1. Fixture: Kohler "Sudbury" K-6652-O, acid resistant cast iron, stainless steel rim guard.
2. Faucet: Chicago Faucet 911 IS, cast or wrought iron copper alloy, combination faucet mounted on wall. Spout shall have pail hook, ¾" hose connection, top or bottom wall brace. Handles on faucets shall be case, formed, or drop forged copper alloy. Escutcheons shall be either forged copper alloy or CRS. Valves shall include concealed integral stops, 8" centers. Elevated vacuum breaker mounted 7'-6" above finished floor. Exposed parts shall be polished chrome plated.
3. Trap: 3" Kohler K6673 trap standard.

2.11 HOSE BIBBS

A. HB-1 Hose Bibb, wall mounted:
1. Fixture: Chicago Faucet 387-E2, 3/4" threaded connection with in-line vacuum breaker. Mount 36" above finished floor.

2.12 WALL HYDRANTS

A. WH-1 Wall Hydrant (Recessed, Freeze-less):
1. Fixture: Woodford Model B65 , chrome box and door, back-flow protected, with loose key operator.

2.13 EMERGENCY SHOWER AND EYEWASHES

A. ES-1 Combination Emergency Shower/Eyewash (Recessed):
1. Fixture: Encon #01112470 combination drench shower and eyewash station, recessed eyewash cabinet with return ABS drain tray system, shower and eyewash valves shall be stay-open chrome-plated brass ball valves, dual anti-surge spray heads and automatic pressure compensation devices

B. ES-2 Combination Emergency Shower/Eyewash (Free-Standing):
1. Fixture: Encon #01050205 combination drench shower and eyewash station, ABS plastic shower head, shower and eyewash valves shall be stay-open chrome-plated brass ball valves, dual anti-surge spray heads and automatic pressure compensation devices, 1-1/4" IPS galvanized iron pipe with 9" floor flange, 1-1/4" IPS supply,

2.14 LABORATORY FIXTURES

A. Laboratory Bench Sink
1. Fixture: Refer to Division 12 - Furnishings
2. Faucet: Refer to Division 12 - Furnishings
3. Drain: Refer to Division 12 - Furnishings
4. Trap: Corrosion resistant P-trap. Material and joint type to match that of discharge waste system, refer to Section 22 6653.

5. Stops and Supplies: Chicago Faucet 1006, angle pattern, lock shield cap, loose key handle, with copper alloy control valve body, stem and gland nuts, 1/2” NPT inlet x 1/2” compression outlet.

B. Laboratory Cup Sink
1. Fixture: Refer to Division 12 - Furnishings
2. Faucet: Refer to Division 12 - Furnishings
3. Drain: Refer to Division 12 - Furnishings
4. Trap: Corrosion resistant P-trap. Material and joint type to match that of discharge waste system, refer to Section 22 6653.
5. Stops and Supplies: Chicago Faucet 1006, angle pattern, lock shield cap, loose key handle, with copper alloy control valve body, stem and gland nuts, 1/2” NPT inlet x 1/2” compression outlet.

C. Laboratory Casework Outlets
1. Fixture: Refer to Division 12 – Furnishings

D. Fume Hoods
1. Fixture: Refer to Division 11 – Equipment
2. Faucet: Refer to Division 11 – Equipment
3. Drain: Refer to Division 11 – Equipment
4. Trap: Corrosion resistant P-trap. Material and joint type to match that of discharge waste system, refer to Section 22 6653.
5. Stops and Supplies: Not required for fume hoods.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install plumbing fixtures as recommended by manufacturer. Caulk around fixtures mounted on irregular surfaces such as tile or stone with silicone sealant, same color as fixture.

B. Support fixtures with proper carrier for each use. Insure that carrier is solidly anchored to prevent rocking whatever piping is used. Anchor bolts in carrier foot shall extend 3" minimum into concrete slab.

C. Fixture carriers shall be suitable for securing each plumbing fixture in place solidly, yet allowing its removal when necessary. Carriers shall be capable of mounting "Barrier Free" fixtures at suitable heights.

D. Install each fixture with trap easily removable for servicing and cleaning. Install fixture stops in readily accessible location for servicing.

E. Install barrier free fixtures in compliance with local code and Federal ADA Accessibility Guidelines. Install barrier free lavatory traps parallel and adjacent to wall and supplies and stops elevated to 27" above finished floor to avoid contact by wheelchair users.

F. Return fixture waste and supply piping into wall as high as practical under fixture. Provide accessible shutoff in fixture supply. Protect "barrier free" supply and drain piping with white colored wrap neatly trimmed to prevent contact with hot or sharp surfaces by user.

G. Coordinate with Electrical Contractor for electronic sensor wiring necessary to install "sensor" operated fixtures. Provide "shockstops" at supplies to solenoid activated fixtures.

H. Provide individual supplies to fixtures and rough-in fixture piping with adequate support to prevent movement fore, aft and laterally. Provide additional blocking as required.

I. Install flush valves for barrier-free water closets with operator handle facing wide side of toilet stall.

J. Provide unions at water connections to drinking fountains and electric water coolers.

3.2 LABORATORY BENCH AND CUP SINKS

A. Set fixture, faucet, eyewash, drain and tailpiece.

B. Make final waste, vent and water connections to fixture.

C. Purified water outlets do not require fixture stops.

3.3 LABORATORY CASEWORK OUTLETS

A. Set fixtures in predrilled casework.

B. Make final connection of fixture to service piping.

3.4 FUME HOODS

A. Set cup sink, faucet, drain and tailpiece.

B. Make final connections to service piping or pre-piped hood. Vent piping for cup sink will not be pre-piped.

3.5 PROTECTION

A. Protect finished surfaces of fixtures from accidental damage or discoloration by use of protective covering.

3.6 CLEANING

A. Prior to Laboratory acceptance, clean fixtures with compounds recommended by manufacturer and remove stains and marks from surrounding walls and countertops.

End of Section

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SECTION 22 40 14

EQUIPMENT BY OTHERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Items specified herein shall be provided by Plumbing Contractor to make equipment provided by others and Laboratory functional.

1.2 RELATED WORK

A. Section 22 11 18 - Water Distribution System

B. Section 22 13 14 - Sanitary Waste and Vent System

C. Section 22 16 00 - Natural Gas Piping

D. Section 22 21 14 - Plumbing Specialties

E. Section 22 66 53 - Corrosion Resistant Waste and Vent System

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions of Contract, Supplementary Conditions, and sections under Division 01 General Requirements.

1.4 SUBMITTALS

A. One package of manufacturer's technical data for all items. Submittal shall be assembled brochure, showing cuts and full detailed descriptions for each item.

B. Shop drawings on items specified herein.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials specified herein shall be new unless otherwise noted.

2.2 LABORATORY FURNISHED EQUIPMENT

A. Where utility services are required for equipment connection, provide the following:
   1. Gas utilities services shall terminate with quick connect outlet; Hanson Coupling #3-HK.
   2. Pressure relief device between isolation valve and quick connect on pressurized gas services; Ross L-O-X Series 15.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Plumbing Contractor shall install items specified herein as recommended by respective manufacturers. Final connections of waste, water, air, gas, etc., shall be installed by Plumbing Contractor as directed by equipment manufacturer. Incidental items, such as, adapters and unions required to make final connection shall be provided by Plumbing Contractor.

B. Coordinate rough-in sizes and elevations with equipment supplier before proceeding with work.

End of Section

SECTION 22 61 14

LABORATORY COMPRESSED AIR SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section covers piping and equipment required to provide laboratory grade compressed air at -40°F dew point at 100 psi as shown on plans and details.

1.2 RELATED WORK

A. Section 20 05 13 - Motors

B. Section 20 05 29 - Mechanical Supporting Devices

C. Section 22 40 14 - Equipment by Others

D. Section 23 05 50 - Vibration Isolation

E. Section 26 29 13 - Enclosed Controllers

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.4 SUBMITTALS

A. Shop drawings on items specified herein.

1.5 PRODUCT DELIVERY

A. Deliver pipe and equipment properly packaged to protect against shipping and handling damage.

B. Installed pipe shall be sealed during construction to prevent construction debris from entering piping system.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials herein specified shall be new unless otherwise noted.

2.2 PIPE AND FITTINGS

A. Above Ground
   1. Copper
      a. Pipe:
         1). Copper tube, Type L hard temper, cleaned and capped, ASTM B819, marked "MED" or similar in accordance with ASTM
      b. Fittings:
         1). Wrought copper, solder joint, pressure rated, cleaned and bagged, ANSI B16.22
      c. Joints: Brazed, silver solder, BCuP-5 type, AWS A5.8, 1250°F melting point minimum.

2.3 UNIONS

A. Copper 3" and smaller:
   1. Wrought copper union, Nibco 733

B. Copper 4" and larger:
   1. Cast red brass flanges, alloy 844, ASTM B584, Class 150, ANSI B16.24 with neoprene gasket

2.4 VALVES

A. Manufacturers:
   1. The following list of valve manufacturers are acceptable subject to providing valves equal to item specified: Nibco, Apollo and Watts

B. Ball Valves:
   1. 3” and Smaller:
      a. Full port, 3-piece, bronze body, stainless steel ball, teflon seats, stainless steel trim, blow-out proof stem, 6” tube extension, oxygen cleaned and bagged, 600 psi CWP; Nibco CS-595-YX-66-EC Series through 2”

2.5 CHECK VALVES

A. Copper Pipe:
   1. Spring loaded, bronze or bronze/stainless steel body, 316 stainless steel spring, straight through flow, shipped bagged and oxygen clean. Apollo Ball-Cone Model 62-100-57.

2.6 PRESSURE REGULATORS

A. Manufacturers: Fisher or approved equal

B. Cast iron body and spring case, t-handle adjustment screw, plated steel control spring, stainless steel plug spring, brass stem and plug spring, neoprene valve seat. Fisher Model 95 Series or approved equal.

2.7 OIL-FREE ROTARY SCREW AIR COMPRESSOR (AC-1, AC-2)

A. Manufacturers: Atlas Copco, Ingersoll-Rand, Kaeser, Kobelco, Quincy

B. Air compressors shall be duplex, air cooled,, two stage, oil free rotary screw units piped in parallel. Compressors shall be base mounted on frames with forklift slots. Compressors shall be factory wired, piped and tested prior to delivery to jobsite.

C. Air compressor enclosure shall include vibration isolation meeting requirements of Section 23 0550 – Vibration Isolation. If enclosure cannot meet requirements of Section 23 0550, enclosure shall be provided with external isolators. Vibration isolators shall not be installed in series.

D. Compressors shall operate in lead/lag/alternate configuration. Panel for compressor control shall be included with package.

E. Each compressor shall be provided with following components:
   1. 10 micron inlet filter
   2. Air intake silencer
   3. Compressor unloading valve
   4. Discharge air check valve

5. Manual compressor isolation valve
6. Air cooled aftercooler
7. Discharge air/water separator
8. 460 V, 3 Ph motor meeting efficiencies listed in 20 0513
9. Capacity as listed in the schedule
10. Duplex control panel shall be NEMA 4 rated enclosure with gauges, controls and indicators to monitor the following operations:
    a. Two magnetic starters
    b. Automatic alternator with three position switch
    c. 120 V control transformer
    d. Intercooler pressure
    e. Compressor discharge pressure gauge
    f. Air cooled
    g. Oil pressure
    h. Low oil pressure alarm
    i. First and second stage outlet air temperature
    j. High first and second stage outlet air temperature alarm
    k. High temperature shut-down switch
    l. Power indicator "ON" light
    m. Run time hour indicator
    n. Hand-off-auto switch
    o. Motor overload alarm
    p. Extra set of dry contacts for general alarm signal to Building Automation System

F. Basis of Design as listed in Air Compressor Schedule.

2.8 AIR RECEIVER (TK-1)

A. Manufacturers: Adamson, Brunner or approved equal

B. Air receiver shall be an ASME rated vertical vessel. Receiver shall have the following components:
1. Ring base with access hand holes
2. Inlet and outlet pressure gauges
3. Safety relief valve
4. Automatic drain device
5. Outlet pressure regulating valve
6. Basis of Design as listed in Tank Schedule.

2.9 DESICCANT AIR DRYER (AD-1, AD-2)

A. Manufacturers: Arrow by McIntire, Atlas Copco, Deltech, Hankinson, Pneumatic Products

B. Air dryers shall be twin tower, heatless regenerative units piped in parallel. Air dryers shall be factory wired, piped and tested prior to delivery to jobsite.

C. Air dryers shall be provided with following components:
1. Duplex inlet coalescing filters with automatic drain device
2. Duplex outlet particulate filters

3. 150 psig rated working pressure
4. Automatic purge cycling based on dewpoint demand
5. Purge air silencers
6. Desiccant chamber pressure relief valves
7. NEMA 4 control panel with following features
   a. Desiccant chamber pressure gauges
   b. Purge air flow indicator
   c. Locally mounted dewpoint indicator
   d. High humidity alarm
   e. Desiccant chamber switch failure alarm
   f. Extra set of dry contacts for alarm monitoring to Building Automation System

D. Basis of Design is as listed in Air Dryer Schedule.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install compressed air piping as shown on drawings and details. Slope piping to drain to low point.

B. Provide flexible connections at compressor inlet and outlet connection points as shown on details.

C. Cut copper tube square and ream before assembly. Keep piping capped during construction to prevent intrusion of construction debris.

D. Support piping drops through finished ceiling from structure above to prevent any lateral or up/down movement. Other outlet drops shall be supported from walls, columns, or workbenches using appropriate hangers, anchors, or Unistrut.

E. Install unions on equipment side of shutoff valves for items such as: air dryers, receiver, compressors, filters, and similar equipment requiring periodic replacement or maintenance.

F. Install vented valve for lock-out/tag-out at connection to equipment. Vented valve shall meet OSHA requirements for disabling power source and bleeding downstream energy.

G. Install temporary plugs and caps on openings during construction phase.

3.2 COPPER PIPING:

A. Threaded Pipe Joints:
   1. Make threaded pipe joints with square cut and reamed pipe. Provide tapered pipe threads in conformance with ANSI B1.20.1.
   2. Cut threads so that exposed threads at joint are less than 3. Coat exposed threads with corrosion inhibiting paint. Use joint compounds or teflon tape on pipe threads to achieve leak free joint.

B. Brazed Copper Pipe Joints:
   1. Brazed joints shall be ASTM Grade 4 or 5 and have melting point at approximately 1250°F. Solder impurities shall not exceed 0.15%.
   2. Tubing shall be delivered to site with original mill caps in place.
   3. Cut tube square, remove burrs from exterior of tube and ream interior of tube before assembly.
   4. Joints shall be cleaned and polished before brazing.

5. Flux of any type shall not be used.
6. Apply heat carefully to prevent damage to pipe, fittings and valves. Disassemble valves where possible to prevent damage to seats during brazing.
7. Purge tube with nitrogen during brazing procedure. Provide manual shut-off valve and check valve as required for purge gas.

3.3 AIR COMPRESSORS

A. Provide wiring necessary for controls and automation systems interface.

B. Air compressor package with components and accessories shall be furnished by one manufacturer. Install components according to manufacturer's recommendations. Consult manufacturer-furnished piping diagrams for interconnecting piping of system components.

C. Installation shall be inspected and approved by manufacturer's field representative. Equipment start-up shall be performed by manufacturer's representative in presence of Laboratory's representative.

3.4 TESTING

A. Refer to testing paragraph of Section 20 0000 - General Mechanical Requirements.

B. Air piping shall be tested at 150 psi for 2 h prior to connection of laboratory fixtures. Soap test each joint to detect leaks during test period. No loss of pressure allowed during test period. Defective joints shall be cut out and replaced. Air piping shall be re-tested at 100 psig for 8 h after final connection of laboratory fixtures.

C. Air compressor equipment shall be delivered pre-assembled and tested by equipment manufacturer.

D. Verify proper signal transmission for each condition specified to Building Automation Controller.

3.5 CLEANING

A. All pipe, fittings and valves will be cleaned by manufacturer. On- or off-site cleaning of any components by Contractor is not allowed. Any components, which have become contaminated, will not be used on any clean systems. They may be used in laboratory vacuum or any water system using copper pipe or fittings.

B. Before system is placed into use, flush piping with product air to remove foreign particles.

3.6 WARRANTY

A. Manufacturer shall warrant air compressor package and components complete, for period of 2 yrs from date of start-up.

End of Section

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SECTION 22 62 14

LABORATORY VACUUM PIPING SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section covers piping and equipment required to provide laboratory vacuum at 19” Hg (19" of mercury) to lab outlets (23" Hg at pump outlet) and vacuum pump equipment as shown on drawings for general laboratory vacuum outlets.

1.2 RELATED WORK

A. Section 20 05 13 - Motors

B. Section 20 05 29 - Mechanical Supporting Devices

C. Section 20 07 00 - Mechanical Systems Insulation

D. Section 22 21 14 - Plumbing Specialties

E. Section 22 40 14 - Equipment by Others

F. Section 23 05 50 - Vibration Isolation

G. Section 26 29 13 - Enclosed Controllers

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.4 SUBMITTALS

A. Shop Drawings on items specified herein

1.5 PRODUCT DELIVERY

A. Deliver pipe and equipment properly packaged to protect against shipping and handling damage.

B. Installed pipe shall be sealed during construction to prevent construction debris from entering piping system.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials as specified shall be new unless otherwise noted.

2.2 PIPE AND FITTINGS

A. Above Ground

1. Copper

a. Pipe: Copper tube, Type L, hard temper, ASTM Specification B88

b. Fittings:
   1). Cast bronze, solder joint, pressure rated, ANSI B16.18
   2). Wrought copper or bronze, solder joint, pressure rated, ANSI B16.22
c. Joints: Lead free (<0.2%) solder, Bridgit or Silvabrite, ASTM B32; flux, ASTM B813

2.3 FLANGES

A. Copper:
   1. Cast red brass, Alloy 844, ASTM B584, Class 150, Standard bolt pattern, ANSI Standard B16.24 with neoprene gasket

2.4 VALVES

A. Copper Piping Systems:
   1. Manufacturers: The following list of valve manufacturers is acceptable unless otherwise noted subject to providing valves equal to items specified: Nibco, Apollo and Watts
   2. Size 4" and Smaller:
      a. Ball Valves: Full port, 3-piece bronze body, quarter turn, stainless steel ball and stem, Teflon seats, blowout-proof stem, 600 psi CWP rated, screwed or soldered joint. Apollo 82-140 Series or Apollo 92-240 Series

2.5 DIELECTRIC FITTINGS

A. Dielectric Flanges (3” and Larger)
   1. Acceptable Manufacturers: Epco Sales Inc., Lochinvar, Watts, Wilkins
   2. Iron female pipe thread to copper solder joint end connections, non-asbestos gaskets, pressure rating of not less than 175 psig at 180°F.

2.6 ROTARY VANE VACUUM PUMP SYSTEM (VP-1, VP-2)

A. Acceptable Manufacturers: Busch, Rietchle-Thomas, Becker, Air-Tech

B. System Description:
   1. Vacuum pump package will be skid mounted and will include receiver tank, vacuum pumps, motors, all electrical components, valves, and piping.
   2. Vacuum pumps will be duplex configuration and a single ASME Rated vertical vacuum receiver. Each vacuum pump will be independently mounted having independent flexible connectors on inlet and outlet of each pump.
   3. Pump package will have single points of connection for vacuum, vacuum exhaust, and electrical. Electrical feed will be 480 V, 3 Ph service. Transformers for devices requiring additional voltage supply will be provided with package.
   4. Vacuum pumps will be air cooled, rotary vane, single stage. Pumps will be direct drive, positive displacement, non-pulsating type. Each pump will have the following:
      a. Totally enclosed, fan cooled (TEFC), continuous duty motor. Suction line 5 micronµm filter, isolation valve, and liquid filled vacuum gauges with isolation valves.
      b. Integral piping and fittings for all components. All pump connections will have flexible connectors.
      c. Each pump suction will be manifolded to one 150 lb flanged connection.
      d. Automatic purge system to flush any gases from pump and prevent condensation as pump cools. Purge system will include isolation valve and actuator, solenoid bleed valve, and controls to operate a 15 minute shutdown purge.

e. Pump drain manifold, piped from each pump oil drain valve.

f. Materials of Construction

1). Vacuum pump: Cast iron casing, non-metallic, non-asbestos vanes, oil lubricated bearings, single mechanical seals

2). Piping: Schedule 40 carbon steel per ASTM A-53 Grade B, threaded 2” and smaller, flanged or welded for piping larger than 2”

3). Base plate: Carbon Steel

C. Pump lubrication will be by an integral, fully recirculating oil supply including oil filter.

D. Vacuum system will be controlled by skid-mounted packaged control system. Programming of vacuum system will be by system vendor. Local duplex Programmable Logic Controller (PLC) will include:

1. UL Listed NEMA 12 Enclosure with across line magnetic starters, circuit breakers, one main fused disconnect, hour meters for each pump
2. Lead-lag pump alternator to control pumps so each pump receives equal run time and rotates through lead pump position, and capability for simultaneous pump operation.
3. Hand-off-auto switch for each pump
4. Manual purge/stop-auto switches for each pump
5. One hundred fifteen volt control transformer with fused primary and secondary
6. Differential type vacuum control switches, field adjustable pump run meters, pump run and alarm lights and audible alarm with silence button, and vacuum gauges, and water temperature read-out devices for each pump, and terminal strip for external conditions.
7. All contacts, vacuum switches, relays, and other necessary accessories. Include extra dry contacts to signal Utility Monitoring System PLC of vacuum switch trips and equipment failures.
8. Frequent start protection with automatic pump shutdown time delay and automatic bypass valve in suction line.

E. Vacuum receiver will be ASME rated for 30" Hg vacuum, galvanized steel. Tank shall be fitted with inlet and outlet flange connections, level gauge, vacuum gauge with isolating valve, sight gauge glass, and tank drain valve. Tank drain valve shall have discharge pipe routed to skid perimeter.

F. Vacuum pump skid shall include vibration isolation meeting requirements of Section 23 0550 – Vibration Isolation. If skid can not meet requirements listed in Section 23 0550, skid shall be manufactured without vibration isolators and external isolation shall be provided. Vibration isolators shall not be installed in series.

G. System Capacity

1. Refer to schedule on drawings for vacuum pump operating capacities and criteria.

2.7 WARRANTY

A. Complete system shall be warranted by manufacturer for 2 yrs from date of startup. Pumps shall be warranted by manufacturer for 5 yrs from startup. This warranty will include parts and labor on items returned to factory for repair and/or replacement. Labor costs associated with on-site warranty repairs shall also be covered by manufacturer and Contractor for minimum 1 yr from date of startup.

B. Complete vacuum pump system shall be completely factory assembled and factory pre-tested prior to shipment to job site.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install vacuum piping as shown on drawings and details. Slope piping to drain to low point.

B. Provide line size cleanout plug at end of corridor distribution mains for flushing out piping.

C. Base-mounted pumps shall be anchored to structure in accordance with seismic restraint requirements. Refer to Section 20 0549 - Seismic Anchorage and Restraints.

D. Provide vibration isolators for base or skid-mounted pumps.

E. Provide wiring necessary for float control switches, safety switches, solenoid valves, and controls interface required. Coordinate power requirements with Electrical Contractor.

F. Flexible connections shall be provided as shown on drawings.

G. Installation shall be inspected and approved by manufacturer's field representative. Equipment start-up shall be by manufacturer's representative in presence of Laboratory's representative.

3.2 PIPING SYSTEMS

A. Piping for Laboratory Vacuum system shall be copper.

B. Piping for Laboratory Vacuum Exhaust shall be CPVC.

3.3 COPPER PIPING:

A. Threaded Pipe Joints:
   1. Make threaded pipe joints with square cut and reamed pipe. Provide tapered pipe threads in conformance with ANSI B1.20.1.
   2. Cut threads so that exposed threads at joint are less than 3. Coat exposed threads with corrosion inhibiting paint. Use joint compounds or teflon tape on pipe threads to achieve leak free joint.

B. Soldered Copper Pipe Joints:
   1. Use non-acidic and lead free flux on cleaned pipe and fittings for soldered joints.
   2. Cut tube square, remove burrs from exterior of tube and ream interior of tube before assembly.
   3. Fill joints with solder by capillary action. Solder shall cover joint periphery. Wipe joint clean.
   4. Apply heat carefully to prevent damage to pipe, fittings and valves.
   5. Follow manufacturer's recommendations when heating valves and equipment for soldered connections.

3.4 CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPING

A. CPVC piping is limited to vacuum exhaust piping.

B. Install in accordance with ASTM D2855 "Making Solvent Cemented Joints with PVC pipe and Fittings". Saw cut piping square and smooth. Tube cutters may be used if fitted with wheels designed for use with PVC pipe that do not leave raised bead on pipe exterior. Support and restrain pipe during cutting to prevent nicks and scratches. Bevel ends 10-15 degrees and deburr interior. Check dry fit of pipe and fittings. Reject materials, which are out of round or do not fit within close tolerance. Use heavy body solvent cement for large diameter fittings.

C. Maintain pipe, fittings, primer and cement between 40 and 100 degrees during application and curing. Apply primer and solvent using separate daubers (3" and smaller piping only) or clean natural bristle brushes about 1/2 size of pipe diameter. Apply primer to fitting socket and pipe surface with scrubbing motion. Check for penetration and reapply as needed to dissolve surface to depth of 4-5 thousandths. Apply solvent cement to fitting socket and pipe in amount greater than needed to fill gap. While both surfaces are wet, insert pipe into socket fitting with quarter turn to bottom of the socket. Solvent cement application and insertion must be completed in less than 1 minute. Minimum of 2 installers is required on piping 4" and larger. Hold joint for 30 seconds or until set, whichever is longer. Reference manufacturer's recommendations for initial set time before handling and for full curing time before pressure testing.

D. Install plastic pipe and fittings as recommended by piping manufacturer. Include adequate offsets or expansion joints to allow for pipe expansion.

E. Provide exhaust terminal through roof with gooseneck return. Terminate 24" above roof. See plans for size and location.

F. When plastic pipe penetrates a fire rated assembly, refer to Section 20 0000 - General Mechanical Requirements, for methods of protection for rated assembly.

G. Do not install plastic pipe in plenum space.

3.5 CLEANING

A. Before system is in use, flush piping with dry compressed air to remove foreign particles.

3.6 TESTING

A. Refer to testing paragraph of Section 20 0000 - General Mechanical Requirements.

B. Vacuum piping shall be tested at 200 psi for 2 h prior to connection of laboratory fixtures. Soap test each joint to detect leaks during test period. No loss of pressure allowed during test period. Vacuum piping shall be re-tested at 100 psig for 8 h after final connection of laboratory fixtures.

C. Test plastic vacuum exhaust piping with air, maintaining pressure of 15 psi for 2 h with no loss in pressure allowed. Inspect all joints in system. Do not conceal any piping until satisfactorily tested. Defective joints shall be repaired and retested. Mercury column gauge shall be used to register air pressure.

D. Vacuum pump equipment shall be delivered un-assembled and pre-tested by equipment manufacturer.

E. Verify proper signal transmission for each condition specified to Building Automation Controller.

End of Section

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SECTION 22 63 14

NITROGEN, CARBON DIOXIDE AND SPECIAL GAS PIPING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies nitrogen, carbon dioxide and special gases, piping and related accessories. Special gas piping system shall include distribution of gases from bulk liquid storage tank(s), from gas cylinder central manifolds, and from localized point-of-use gas cylinder manifolds to terminal devices at individual points of use throughout the building.

B. (Special gases shall include but not be limited to Nitrogen/Hydrogen).

1.2 RELATED WORK

A. Section 20 05 29 - Mechanical Supporting Devices

B. Section 20 05 53 - Mechanical Systems Identification

C. Section 22 40 14 - Equipment by Others

D. Section 22 62 14 - Laboratory Vacuum Piping System

E. Section 22 61 14 - Laboratory Compressed Air System

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. Items listed as “Cleaned for Oxygen Service” shall comply with requirements of CGA Standard G-4.1, Cleaning Equipment for Oxygen Service.

1.4 SUBMITTALS

A. Shop drawings on items specified herein.

PART 2 - PRODUCTS

2.1 PIPE

A. Above Ground:
1. Copper
a. Pipe:
1). Copper tube, hard temper, cleaned and capped, ASTM B819, marked “MED” or similar in accordance with ASTM
b. Fittings:
1). Cast bronze, solder joint, pressure rated, cleaned and bagged for oxygen service, ANSI B16.18
2). Wrought copper or bronze solder joint, pressure rated, cleaned and bagged for oxygen service, ANSI B16.22

c. Joints: Brazed, silver solder BCuP-5, AWS 5.8, 1250°F melting point minimum

2. Stainless Steel

a. Pipe: Stainless steel tubing, Type 316, ASTM A213, ASTM A269, hardness not to exceed Rb80, fully annealed, seamless tubing, free of scratches, burrs and surface defects, suitable for bending and flaring for sizes 1/16" through 2", cleaned for oxygen service. Minimum pipe wall thickness shall meet the following requirements:

Pipe Size (inches)	Minimum Wall Thickness(inches)	Maximum Working Pressure(psi)
1/8	.028	8,500
1/4	.028	4,000
3/8	.049	4,800
1/2	.065	5,100
5/8	.065	4,000
3/4	.065	3,300
1	.083	3,100
1-1/4	.120	3,600
1-1/2	.134	3,400
2	.188	3,600

b. Fittings and Joints: Type 316 stainless steel, double ferrule, compression by male, or compression by female tubing fittings, cleaned and bagged for oxygen service.

1). Acceptable manufacturers: Parker, Swagelok, SSP Instrumentation, Tylok

2.2 FLEXIBLE CONNECTORS

A. Acceptable Manufacturers: Saint-Gobain or approved equal

B. Teflon smooth inner tube with outer 304 stainless steel braid, stainless steel crimped on end connections, -100°F to 450°F continuous temperature rating, 500 psig maximum working pressure, cleaned and capped for oxygen service.

C. Saint-Gobain TS series

2.3 UNIONS

A. Copper 3" and smaller:

1. Wrought copper union, Nibco Fig. 733. Mueller brass equal.

B. Stainless Steel 2" and smaller:

1. Swagelok Type 316 stainless steel, double ferrule tubing coupling

2.4 VALVES

A. Copper:

1. Ball Valve

a. Size 2” and Smaller:

1). Acceptable manufacturers: Apollo, Nibco, Watts

2). Full port, 3-piece, bronze body, quarter turn lever handle, stainless steel ball and blow-out proof stem, stainless steel trim, Teflon seats and seals, 6” tube extension, oxygen clean and bagged, 600 psi CWP rated, Apollo 82-240-57

B. Stainless Steel:

1. Ball Valve

a. Size 2” and Smaller:

b. Acceptable manufacturers: Parker, SSP Instrumentation, Swagelok, Tylok

1). Full port, 3-piece, stainless steel body, quarter turn level handle, stainless steel ball and blow-out proof stem, stainless steel trim, Swagelok or NPT ends, reinforced Teflon seats and seals, oxygen cleaned and bagged, 600 psi CWP rated. Swagelok Series 60.

2.5 PRESSURE REDUCING VALVES

A. Acceptable Manufacturer: AGA/Linde, Norgren, Tescom

B. Regulator shall be made from high purity brass or stainless steel barstock and have Hastelloy diaphragms. Regulator shall have 0-85 psig outlet pressure range and be provided with outlet pressure gauge. Gauge shall be selected such that operating pressure is in center of gauge pressure range. Inlet and outlet connections shall be 1/4” female NPT minimum.

C. Refer to schedule on drawings for flow rate and pressure requirements of each regulator.

2.6 FILTERS

A. Coalescing Filters

1. Acceptable Manufacturers: Balston, Dominick Hunter, Matheson, Pall, or approved equal
2. Filter element shall be 99.99% efficient at 0.1 micron
3. Filter housing shall be stainless steel with auto-drain device, viton seals, and be rated for 250 psig working pressure. Pipe discharge from auto-drain to nearest floor drain.
4. Balston Grade BX with Model 45S6 housing.

B. Particulate Filter

1. Acceptable Manufacturers: Balston, Dominick Hunter, Matheson, Pall, or approved equal
2. Filter element shall be 99.99% efficient at 0.1 micron
3. Filter housing shall be stainless steel with viton seals and be rated for 250 psig working pressure.
4. Balston Grade AQ with Model 45S6 housing.

2.7 SPECIAL GAS MANIFOLDS

A. Carbon Dioxide, Helium, Nitrogen, Nitrogen/Hydrogen mix

1. Acceptable manufacturers: AGA/Linde, Matheson, Spectra Gas
2. Manifolds shall be high-purity semi - automatic style suitable for gas purities up to 99.999 percent and be cleaned for oxygen service. Manifold shall accommodate one primary cylinder and one secondary cylinder with automatic changeover from primary cylinder to secondary cylinder. Manifolds shall include:

a. Regulators shall be manufactured from high purity brass barstock materials and contain a brass diaphragms.

b. Manifolds shall be suitable for inlet pressures up to 3000 psig and deliver gas in the rane of 0-125 psig.

c. Manifolds shall be equipped with purge valves to allow purging of cylinders while in use. Flow limiters shall be provided on purge lines.

d. All manifold valves shall be 1/4 turn ball valves.

e. Manifolds shall include stainless steel pigtails with appropriate CGA fittings.

f. Manifolds shall have gauges with inductive style contacts for alarm signals.

g. Relief valve for protection of manifold from overpressure. Relief valve shall accommodate maximum flow from failed regulator while maintaining system pressure or below design pressure.

3. Changeover from primary to secondary supply shall take place automatically when primary supply becomes depleted. When depleted bank of cylinders is replenished, actuation of a clearly marked, easily operable lever on each bank regulator shall cause replenished bank to become secondary or reserve supply without requiring opening or closing of multiple bypass valves. Repositioning of operating levers shall expose indicator labels that clearly show if manifold has been properly reset and which bank is primary supply and which is secondary supply.

4. Basis of Design: AGA/Linde Model A208.

5. Manifold shall be set to deliver gas at listed pressures:

a. Carbon Dioxide: 30 psig

b. Nitrogen: 100 psig

c. Nitrogen/Hydrogen: 0-100 psig

PART 3 - EXECUTION

3.1 INSTALLATION

A. Nitrogen and Carbon Dioxide Piping: Gaseous nitrogen and carbon dioxide piping shall be installed according to requirements of CGA pamphlets and as shown on drawings.

B. Piping shall be installed above ground in buildings. Protect pipe openings during construction to prevent introduction of dirt and debris.

C. Shutoff valves shall be accessible in case of emergency; installed minimum of 5 ft from each piece of equipment.

D. Identify gas services during installation so that the chance for cross over of one gas service to a different terminal unit is avoided. Do not depend on test procedure listed herein to identify cross connections.

E. Manifold relief valves shall be piped to exterior or other appropriate points. Avoid discharging close to windows, doors and air intake louvers.

F. Changes in direction shall be made by use of fittings. No pipe bending allowed. Pipe size reductions shall be by use of reducing fittings, no bushings allowed.

3.2 COPPER PIPE

A. Threaded Pipe Joints:

1. Make threaded pipe joints with square cut and reamed pipe. Provide tapered pipe threads in conformance with ANSI B1.20.1.

2. Cut threads so that exposed threads at joint are less than 3. Coat exposed threads with corrosion inhibiting paint. Use joint compounds or teflon tape on pipe threads to achieve leak free joint.

B. Brazed Copper Pipe Joints:

1. Brazed joints shall be ASTM Grade 4 or 5 and have melting point of approximately 1250°F. Solder impurities shall not exceed 0.15%.

2. Tubing shall be delivered to site with original mill caps in place.

3. Cut tube square, remove burrs from exterior of tube and ream interior of tube before assembly.

4. Joints shall be cleaned and polished before brazing.

5. Flux of any type shall not be used.

6. Apply heat carefully to prevent damage to pipe, fittings and valves. Disassemble valves where possible to prevent damage to seats during brazing.
7. Purge tube with nitrogen during brazing procedure. Provide manual shut-off valve and check valve as required for purge gas.

3.3 STAINLESS STEEL

A. Swagelok fittings and tubing shall be installed according to manufacturer's recommendations.

3.4 CLEANING

A. Piping and components that are provided "Cleaned for Oxygen Service" shall not require cleaning. Flush system with source gas until 100% concentration of service gas is verified at all outlets.

B. For components not provided "Cleaned for Oxygen Service" and components where cleanliness has been compromised, pipe and fittings shall be thoroughly cleansed of oil, grease, dirt or other contaminating materials by washing in a hot solution of sodium carbonate or trisodium phosphate mixing in proportions of 1 pound to 3 gallons of water. Scrubbing shall be employed where necessary to obtain complete cleaning. After washing, materials shall be rinsed thoroughly with clean hot water and dried with dry nitrogen. After cleaning, tubing, fittings, and valves shall be plugged or wrapped until item is to be installed. Particular care must be exercised in handling and in conditions of tools used to prevent oil and grease being introduced. If contamination has occurred, affected items must be rewashed.

C. Before actuation of gas supply, systems shall be flushed with dry nitrogen to ensure a clean system free of oil and construction debris. Nitrogen shall then be purged by source gas until 100% concentration of source gas is verified at all gas outlets for that service gas.

3.5 TESTING

A. Refer to testing paragraph of Section 20 0000 - General Mechanical Requirements.

B. Pressurize piping system prior to connection of laboratory fixtures and check for leakage by examining each joint by means of Oxweld No. 23 Leak Test Solution or other non-frothing solutions approved for this purpose.
   1. Gaseous carbon dioxide piping shall be pressurized with dry nitrogen at 150 psi.
   2. Gaseous nitrogen system shall be pressurized with dry nitrogen at 150 psig.
      a. Special gas piping systems shall be pressurized with oil free compressed air or dry nitrogen at 150 psig.

C. Test pressure shall remain in piping for at least 2 h. Source pressure shall be shut off and pipe temperature at beginning and end of test shall be recorded. Pressure changes, other than that caused by temperature change, will not be permitted.

D. Provide final pressure test at 100 psig for 8 h after connection of laboratory fixtures.

E. Test operation of pressure switches and verify that signals are properly transmitted.

3.6 CERTIFICATION

A. Cross-over test shall be performed by independent testing agent hired by Contractor.

B. Testing agency shall certify that terminal units are connected to proper gas piping system. Test shall be done in conformance with requirements of NFPA 99.

C. As part of certification test, all alarms should be actuated and checked for proper setting and wiring to alarm panels.

D. As a last check, special gas systems shall be purged of test gas and oxygen terminal units shall be analyzed to insure proper oxygen concentration is delivered through each oxygen terminal unit.

E. Certification test report shall be submitted to Architect and Engineer for review prior to use of special gas systems. Systems shall not be considered in service until satisfactory test results are submitted and approved.

End of Section

SECTION 22 63 15

LIQUID NITROGEN SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies materials and methods for complete liquid nitrogen system to supply LN_2 to recharge dewars.

1.2 RELATED WORK

A. Section 20 05 29 - Mechanical Supporting Devices

B. Section 22 21 14 - Plumbing Specialties

C. Section 22 40 14 - Equipment by Others

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Special Conditions, and sections under Division 01 General Requirements.

1.4 QUALITY ASSURANCE

A. Substitution of Materials: Refer to Section GC - General Conditions of the contract, Article 7.

B. Codes and Standards:
   1. ANSI American National Standards Institute
   2. ASTM American Society for Testing and Materials
   3. NFPA National Fire Protection Association

PART 2 - PRODUCTS

2.1 MATERIALS

A. Material shall be new unless otherwise noted.

2.2 MANUFACTURERS

A. Equipment specified herein shall be supplied by Chart Industries, Technifab Products, Vacuum Barrier Corporation (VBC), or approved equal. All products shall be supplied from same manufacturer.

2.3 PIPE

A. Design Criteria:
   1. Inner Carrier: Design and manufacturing of vacuum insulated pipe shall be in accordance with ANSI B31.3 - Chemical Plant and Petroleum Refining piping and latest applicable addenda for 150 psi.

B. Vacuum Insulated Stainless Steel
   1. Pipe:
      a. Stainless steel, Type 304, ASTM A312, welded or seamless, bellows pipe. Bayonet pipe ends for jointing spools and at use points.
      b. Invar 36 welded
   2. Jacket:
      a. Stainless steel, Type 304, ASTM A312 welded pipe, bellows pipe. Vacuum Jacket shall be designed in accordance with ASME code for Unfired Pressure Vessel, Section VIII for internal vacuum and external atmospheric pressure with assembly at ambient temperature.
      b. Stainless steel, Type 304, ASTM A312 welded pipe. Vacuum Jacket shall be designed in accordance with ASME code for Unfired Pressure Vessel, Section VIII for internal vacuum and external atmospheric pressure with assembly at ambient temperature.
   3. Fittings: Stainless steel, Type 304, vacuum insulated, bayonet ends
   4. Joints: Butt Welded

2.4 PIPING SPECIALTIES

A. Gas Vent
   1. Vacuum jacketed, stainless steel, float operated device with bayonet ends designed to vent gas from inner pipe to maintain liquid delivery. Vent side shall have isolation valve. Chart Industries Cryovent Model B or approved equal.

B. Liquid Nitrogen Dewar Fill Station
   1. Liquid nitrogen dewar fill station to allow for unattended filling of dewars. LN2 supply to automatically shut off at the presence of LN2 on the filling sensor. Fill station to be Chart Model 269 or Vacuum Barrier Corporation Nitromatic, or approved equal.

2.5 VALVES

A. Vacuum insulated, globe pattern, straight or Y pattern handle, 304 stainless body and trim, butt weld ends.

B. Relief Valves:
   1. Pilot operated, stainless steel body and trim, pressure relief type.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Expansion joints shall be installed in jacket pipe of each spool as required to compensate for differential rates of expansion and concentration between inner carrier and jacket pipe.

B. Design - Normal movement with minimum pressure design as follows:
   1. External Pressure: 20 psig with internal vacuum
   2. Internal Pressure: 35 psig
   3. Cycle Life: 5000 cycles

C. Vacuum Annulus:
   1. Spacers: Inner carrier shall be supported within jacket by support system designed to absorb thermal loads on inner pipe when partially or completely filled with product, to minimize heat leakage, withstand loadings (a, b, and c below) during shipping and loading, and (d) during and after installation.

a. Three "g" load applied vertically downward
b. Three "g" load applied vertically upward
c. Two "g" load applied horizontally, longitudinally, or laterally combined with one "g" load vertically downward
d. Meet uniform building code for Zone 3 seismic requirement when inner line is filled with Trichlorethylene.

D. Laminar Radiation Shielding: Inner line shall be "super insulated" with minimum of 15 alternate layers of aluminum foil and Dexter glass fiber paper.

E. Chemical Gettering System: Each spool shall have molecular sieve and hydrogen converter installed in vacuum annulus for purpose of removing majority of vacuum contaminants released by outgassing. Quantity of sorption pumping materials required for each spool section shall be determined by MVE.

F. Evacuation Port: Each spool shall be equipped with MVE combination evacuation/relief valve port complete with Hastings DV-6R vacuum transducer for monitoring vacuum level without breaking into vacuum annulus.

G. Location shall be in approved location or approximately centered on each spool with consideration to personnel safety, accessibility, and non-interference with other equipment.

H. Manufacturing:
1. Shall be accomplished through use of certified welders. Welder's certification to be submitted upon request. Work accomplished under supervision of certified welder shall not be considered equal to work done by certified welder.

I. Evacuation:
1. Heat shall be applied during pumping to accelerate outgassing. Minimum temperature shall be 200°F. Spools to be sealed at less than 10 microns.

J. Means shall be employed on vacuum pumping system to prevent oil from backstreaming into spool vacuum space.

3.2 CLEANING

A. Procedures shall be submitted for customer approval.

3.3 TESTING

A. Welds shall be leak-tested with helium mass spectrometer calibrated to sensitivity of 1 x 10^9 standard cc/second.

B. Vacuum Retention Test: Each spool shall be tested over two-day period with spool isolated from pump at ambient temperature. Pressure in annular space shall be measured every 24 h and recorded. Spools will be acceptable if:
1. There is pressure rise of 8 microns or less. Pressure greater than 8 microns will require one additional day of vacuum retention. Line shall be considered acceptable if third day's reading indicated vacuum is stable.
2. Maximum stabilized pressure before shipping is 35 microns. (Consult factory for seven-day or greater retention).

End of Section

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SECTION 22 66 53

CORROSION RESISTANT WASTE AND VENT SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies pipe, fittings, equipment and methods for corrosion resistant waste and vent piping system installed to 5 ft outside the building wall.

1.2 RELATED WORK

A. Section 20 05 20 - Excavation and Backfill

B. Section 20 05 29 - Mechanical Supporting Devices

C. Section 22 21 14 - Material Specialties

1.3 REFERENCE

A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.4 SUBMITTALS

A. Shop drawings on items specified herein.

B. Submit Manufacturer's technical data for the following:
   1. Pipe and fittings
   2. Joints
   3. Floor drains
   4. Cleanouts

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use new materials unless otherwise noted.

2.2 PIPE

A. Underground:
   1. Polypropylene (PP)
      a. Pipe: PP, Schedule 80, non-flame retardant, ASTM D4101, plain end.
      b. Fittings: PP, Schedule 40, non-flame retardant, drainage pattern, socket fusion.
      c. Joints: Socket fusion.
      d. Manufacturers: Enfield "Enfusion", George Fischer "Fuseal", Orion "Rionfuse"
   2. High Silicon Cast Iron
      a. Pipe:
         1). Duriron, hubless pattern, service weight, silicon content of 14.5%; ASTM A-518.
         2). Duriron, hub and spigot, extra heavy, 14.5% silicon content; ASTM A-518.

b. Fittings:
   1). High silicon cast iron, service weight, hub and spigot, silicon content of 14.5%, ASTM A-518.
   2). High silicon cast iron, service weight, hubless, silicon content of 14.5%; ASTM A-518.
c. Joints:
   1). Hub and spigot.
   2). Heavyweight couplings, 0.060" thick stainless steel clamps. Duriron “MJ” coupling.
d. Manufacturers: Flowserve Corporation.

B. Above Ground:
1. Polypropylene (PP)
   a. Pipe: PP, Schedule 40, ASTM D4101, flame retardant in conformance with ASTM D635, plain end.
   b. Fittings: PP, Schedule 40, flame retardant in conformance with ASTM D635, drainage pattern, socket fusion.
   c. Joints: Socket Fusion
   d. Manufacturers: Enfield "Enfusion", George Fischer "Fuseal", Orion "Rionfuse", Zurn.
2. Polypropylene (PP)
   a. Pipe: PP, Schedule 40, ASTM D4101, flame retardant in conformance with ASTM D635, grooved end.
   b. Fittings: PP, Schedule 40, flame retardant in conformance with ASTM D635, drainage pattern, mechanical joint.
   c. Joints: Mechanical.
   d. Manufacturers: Enfield, George Fischer "Fuseal MJ", Orion "Riontite", Zurn.

2.3 ADAPTERS

A. Provide where indicated and as necessary; glass to plastic compression coupling, plastic to metal mechanical joint, or glass to metal mechanical joint and/or compression coupling.

B. Plastic to plastic 1” through 4”: Fernco Proflex 3000 Series shielded coupling with neoprene gasket, stainless steel shield, and stainless steel clamping bands.

C. Submit adapter fittings for approval prior to installation.

2.4 CLEANOUTS

A. Corrosion resistant materials similar to piping materials. Refer to Cleanout Schedule on drawings.

2.5 FLOOR DRAINS

A. Refer to Drain and Cleanout Schedule.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install piping neat and orderly; accomplish changes of direction using proper pipe fittings. Connect to sinks, cup sinks, floor drains, and other devices as shown on drawings. Conceal piping unless noted to be exposed in reagent rack. Piping within casework shall be coordinated with casework supplier.

B. Pitch vent piping to waste line. Install horizontal waste piping with minimum pitch of 1" in 4 ft; except piping 3" and larger may pitch 1" in 8 ft. Make changes in direction of flow by use of drainage pattern fittings.

C. Set floor drains level and at low points. Protect weep holes from filling with concrete. Clamp safing to drain body for proper drainage.

D. Install cleanouts as shown on drawings. Locate cleanout access cover so that snake of 100 ft can be properly used.

E. Provide caps and plugs on open pipe ends during construction phase to prevent construction debris from entering pipe.

F. Provide necessary transition fitting and couplings required when changing from one piping material to dissimilar material.

3.2 HIGH SILICON CAST IRON

A. Install hubless pattern high silicon cast iron pipe and fittings as recommended by manufacturer. Mechanical joints shall be tightened to proper torque. Provide adequate support for horizontal and vertical piping according to manufacturer’s recommendations and as specified in Section 22 1118 - Water Distribution System.

B. Joints for hub and spigot high silicon cast iron shall be made using Red Stripe Sealite Rope Packing acid resistant asbestos-free rope packing impregnated with acid resistant lubricant. Pipe hub shall be caulked 1/2 full of specified packing and caulked with molten lead. Fill with lead to top of hub and face off.

3.3 PLASTIC PIPING

A. Install plastic pipe and fittings as recommended by respective manufacturer. Fuse plastic pipe joints with surrounding temperature above freezing using equipment supplied by pipe manufacturer. Adhere to instructions for fusing as published by manufacturer. Instructions for fusing shall be kept on site.

B. Install mechanical joints in accordance with instructions from pipe/fitting manufacturer. Use materials of same manufacturer, especially made for mechanical jointing. Use pipe and fittings with factory cut groove, except pipe may be grooved in field using equipment and methods as recommended by manufacturer of pipe. Use hangers on each side of mechanical couplings.

C. Manufacturer's representative shall instruct workmen in proper installation techniques required and provide certification to Laboratory that instruction has been given and proficiency demonstrated by Contractor in execution of installation of piping system.

D. Do not install PP material in plenum space. Refer to HVAC drawings to determine plenum spaces.

E. Use special precautions and approved/listed systems when PP material penetrates fire resistive or smoke barrier. Refer to Section 20 0573 - Mechanical Systems Firestopping.

F. Do not use plastic pipe when high temperature (above 100°F) water (at autoclaves, sterilizers, glasswashers, and similar devices) is discharged to receptor or drain. Provide minimum of 25 ft of glass or high silicon cast iron piping material downstream of high temperature drain discharge point.

3.4 TESTING

A. Hydrostatically test to 5-psi pressure. Maintain 5-psi hydrostatic pressure for 2 hrs without leakage.

B. Replace or repair piping system until satisfactory test is obtained. No piping shall be concealed until satisfactorily tested.

3.5 CLEANING

A. After successful pressure test, clean and flush piping system to eliminate debris in drainage system.

End of Section

SECTION 22 67 14.13

PLASTIC PIPING FOR HIGH PURITY SERVICE

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section covers requirements for procurement, installation, inspection, and sanitization of Polypropylene (PP) piping, fittings, valves, and specialties for High Purity Water (HPW) service.

B. HPW system is defined by:
   1. This document
   2. Flow diagrams P5.1.4
   3. Sections under Related Work below.

C. HPW piping is defined as piping downstream of RO system.

1.2 RELATED WORK

A. Section 20 0529 - Mechanical Supporting Devices

B. Section 20 0573 - Mechanical Systems Firestopping

C. Section 22 6720.13 - High Purity Water System Equipment

1.3 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.4 SCOPE OF WORK

A. Contractor shall be responsible for procurement, installation, inspection, and sanitization of piping system.

B. Contractor shall provide personnel trained and experienced in installation of selected manufacturer's piping system. If personnel are not experienced at start of installation, piping manufacturer's representative shall train Contractor prior to installation. Training certification and experience record is required.

C. Contractor shall submit documentation on components proposed for system and shall obtain approval prior to purchase or fabrication of those components.

D. Contractor shall inspect system and provide documentation to demonstrate that system is installed according to Specification, is leak free, and has been sanitized according to procedure.

1.5 BASIS OF DESIGN

A. Service: HPW
   1. Process Fluids: high purity water; 1% peracetic acid solution, or 5% hydrogen peroxide solution
   2. Operating Pressure/Temp. 100 psig at 80°F

3. Piping System
   a. Required Pressure Rating: 144 psig at 68°F for components
   b. Material: PP as specified below.
      1). Joining method: Infrared butt fusion
         2). Elastomer: EPDM

B. The following items must be submitted for review, and approved prior to purchase of item:
   1. Detailed descriptions of pipe, fittings, valves, and other components.
   2. Identification of joining method and fusion equipment.
   3. Detailed Sanitization Procedure (see Part 3.1).
   4. Training certification for installation personnel.

C. The following documentation is required to be delivered with system:
   1. Pressure Test Report
   2. Sanitization Records
   3. Manufacturer's material certifications
   4. Record of fusion machine operating parameters for every joint
   5. Joint inspection records

1.6 DELIVERY

A. Pipe, fitting, and components shall be furnished with plastic end-caps/plugs to prevent contamination and damage.

B. Pipe, fitting, and components shall be furnished in individually sealed bags to prevent contamination.

C. Pipe, fittings, and components shall be handled and shipped so as to protect from contamination and damage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. PP: Georg Fischer, Sani-Tech, Simtech

2.2 GENERAL

A. Piping, fittings, and valves that are to be heat fused shall be products of same manufacturer.

B. Piping, fittings, valves, gaskets and accessories shall be compatible with Design Conditions in Part 1.5 as stated above.

C. Dimensions of end connections for valves shall be compatible with pipe and fittings.

D. Materials in contact with water shall be FDA approved for sanitary product contact surfaces.

E. Pipe and fittings shall be permanently identified with production lot and wall thickness or pressure rating.

F. Piping, fittings, valves, and components shall be manufactured in dedicated equipment in clean environments and bagged.

G. Material Certification Documentation shall be furnished for piping, fittings, valves, and components.

2.3 PIPE, FITTINGS, & JOINTS

A. Polypropylene (PP)
   1. Material: polypropylene compound conforming to Standards of ASTM D-4101
   2. Pipe, fittings, and valves: Georg Fisher “Beta PP”, PP-Pure” or Sanitech SaniPro-T
      a. Fused joints
         1). Non-Contact Infrared (IR) butt fusion
      b. Mechanical Joints
         1). Tri-Clamp or sanitary union
         2). Mechanical joints to be used only where indicated on P&ID. Use in other locations requires prior approval.
      c. Connections at equipment (only)
         1). Flange adapter with Georg Fisher V-Flange ring with bolt holes per ANSI B16.5, Class 150 pattern
         2). For mating with FRP flange, flat gasket shall be Garlock "Stress Saver", PTFE, or approved equal
         3). For mating with stainless steel flange, flat gasket shall be Garlock Gylon 3545 or Georg Fisher Sygef HP Gasket.

2.4 VALVES

A. General
   1. Valves shall be same material and manufacturer as piping.
   2. Valves shall conform to Basis of Design in Part 1.5 above.
   3. End Connections shall be spigot ends for Non-contact infrared butt fusion or, if indicated on P&IDs Tri-Clamp or flanged ends.

B. PP Valves
   1. Diaphragm Valves
      a. Weir type, self-draining, PTFE diaphragm backed by EPDM, non-rising stem, position indicator, stroke limit stops.
      b. Size 2" and smaller: Georg Fischer Type 315
      c. Size 2-1/2" and larger: Georg Fischer Type 317
      d. Zero static valve: Georg Fischer Type 319
   2. Ball Valves
      a. True union type, full port, Viton seals, Teflon seats
      b. Georg Fisher Type 346
   3. Sampling valves
      a. Zero static tee diaphragm valves, 1/2"
      b. Millipore Sanitary ESP sampling valve YY20040H0, 1/4“ Halar, NPT
      c. Millipore Sanitary ESP sampling valve YY20040S0, 1/4“ stainless steel, NPT
   4. Self Contained Pressure Regulating Valves
      a. PTFE, EPDM backed diaphragm and Viton O-rings
      b. Relief valves to be Georg Fisher V85 or equal
      c. Retaining (back pressure) valves to be Plast-O-Matic RVDT, Georg Fisher V786, or Jordan Steriflow Mark 95.

d. Reducing valves to be Georg Fisher V82, Jordan Steriflow Mark 96, or Plast-O-Matic RVDT.

e. Sizing is per Equipment Schedule.

5. Check Valves

a. 2" and smaller: Ball check valves, Viton seals, PP ball, Georg Fisher Type 360, or approved equal

C. Actuators

1. Valve actuators for on/off control to be provided integral to valve by manufacturer of valve.
2. Actuator type (pneumatic/electric) shall be as indicated on P&ID. Position switches shall be provided if indicated on P&ID.

2.5 SPECIALTY ITEMS

A. Orifice Plates

1. Manufacturers: Rubber Fab Mold and Rubber Co., Newman Gasket Co., or Georg Fischer
2. Flow restriction orifice plates shall be 316L stainless steel with minimum finish of 25 Ra, Kynar, for installation in Tri-clamp or sanitary union.
3. Orifice plates shall be tagged with instrument number and orifice bore size.
4. Orifice plates shall be concentric or eccentric depending upon installation orientation
5. Orifice specification and preliminary sizing information is shown in Equipment Schedule. Sizing information shall be verified by Engineer after Contractor submits drawings.

B. Flexible Sections

1. Flexible sections indicated on drawings shall be convoluted FDA Approved Teflon with external polypropylene reinforcing braiding and tri-clamp connections. Teflon inner core is extended through flange and flared to form gasket. Backing flange to be PVDF with 150 # ANSI dimensions. Flexible sections shall be rated for at least 150 psig.

C. Faucet Connections

1. Tubing for connection to lab faucets shall be polypropylene, or PFA tubing, 3/8" OD; 0.062" wall, rated to at least 150 psig at 80°F. Polypropylene tubing shall be made from virgin copolymer conforming to FDA requirements for food contact.

2.6 INSTRUMENTATION

A. Instrumentation Specifications are covered in Section 22 6720.13.

PART 3 - EXECUTION

3.1 GENERAL

A. Install and inspect piping and accessories as per Contract Documents and recommendations of equipment manufacturers.

B. Provide installation personnel who are trained and experienced with assembly of selected piping in high purity systems.

C. Provide installation personnel who are certified by piping manufacturer for specified joining method.

D. Provide diaphragm valves or type of valves as indicated on drawings.
   1. Inspect delivered components to verify conformance to specification and to check for evidence of damage or contamination. Do not use suspect materials.

E. Maintain high level of cleanliness during handling and installation.
   1. Prior to starting work, identify areas that will be used for storage and fabrication, and take measures to prevent contamination from adjoining areas.
   2. Handle and store tubing, fitting, and components in a manner that prevents impact damage, excessive stress, and contamination.
   3. Maintain manufacturer's protective packaging in place until immediately prior to use.
   4. Keep openings on assemblies sealed during fabrication to prevent contamination prior to final installation.

F. Install piping using minimum number of joints.

G. Monitor and inspect installation process to ensure:
   1. Conformance with this Specification.
   2. Compliance with manufacturer’s requirements.
   3. Piping is supported as specified.

3.2 INSTALLATION

A. PP Joint Fabrication
   1. Perform joining in strict accordance with manufacturer's recommended procedures with manufacturer's specified equipment.
   2. Fabricate in clean area. Provide ventilation to room isolated from areas where grinding or welding of metals is occurring.
   3. Cut piping in strict accordance with manufacturer's recommended procedures.
   4. Clean components prior to fusion conscientiously and in strict compliance with manufacturer's recommendations for high purity services.
   5. Form joints using non-contact butt fusion with equipment made specifically for this use by manufacturer of this material. Use equipment that is capable of generating record of operating conditions for each joint.
   6. Label joints for traceability.
   7. Record operating conditions of fusing equipment for each joint.
   8. Use sanitary union or Tri-clamp joints only where indicated on drawings or where necessary to connect to accessories and equipment. Verify that gasket is correctly indexed prior to tightening. Tighten hand tight only; do not use tools.
   9. Provide ANSI flanged joints only for connecting to equipment that does not have Tri-Clamp fittings available. Tighten flanged connections in strict accordance with manufacturer's recommendations. Threaded joints are not acceptable.

B. Configuration
   1. Horizontal runs shall be continuously supported by equal leg aluminum, stainless steel, or galvanized steel "V" channel under pipe. Support tubing in strict accordance with manufacturer's recommendations for a maximum deflection of 0.01” per foot at operating temperature stated in part 1.5 above or 30°C, whichever is higher. In additional to these supports, supports shall be provided at all changes of direction.
   2. Install tubing so that there are no undrainable pockets. Slope tubing minimum of 1/8" per foot towards use points or low point drains so that 100% of the water in system will drain freely.

3. Provide adequate support of pipe at pump discharge.
4. Orient diaphragm valves per manufacturer's instructions to ensure complete drainage.
5. Install check valves and orifice plates in vertical sections. If installation in horizontal is required, provide eccentric valve or plate and orientate properly.
6. Provide low point drains and high point vents in compliance with drawings and Engineering review of isometric drawings.
7. Rough or sharp edges must not be in contact with pipe.
8. Erect tubing without spring or force. Connect to equipment such that stress is not transferred to equipment.
9. Install all tee connections so as to minimize dead leg. Distance from sealing point on branch to inside of main line wall shall be less than four branch line diameters.
10. Route lines so as to accommodate thermal expansion where required. Provide supports appropriate for thermal expansion. Install supports so that movement of piping due to thermal expansion is not impeded.

C. In-Line Devices
1. Locate and orient in-line specialty items and instrumentation so as to allow for access after insulation is installed, including:
   a. Access for maintenance and calibration.
   b. Viewing of gauges by operating personnel.
   c. Clearance for removal of regularly replaced components (filter elements, UV lamps, etc.)
   d. Convenient operator access to sample valves and insertion of sampling container.
2. Install in-line specialty items and instruments such that they are free draining.
   a. Install restriction orifices in vertical section of pipe unless. If orifice must be in horizontal run, use an orifice that is eccentric drilled and orientate with hole at low point.
   b. Install in-line specialty items and instruments in strict accordance with manufacturer’s instructions.
   c. Install sensors for conductivity and resistivity in run of a horizontal tee with flow exiting upward branch.
   d. Provide length of straight pipe upstream and downstream of flowmeters. As specified by manufacturer.
   e. Install pressure regulators and backpressure regulators with at least 10 pipe diameters of straight pipe upstream and downstream of regulator.
   f. Install sanitary orifice plates in sanitary unions or in Tri-Clamp joints as indicated on drawings. Clearly tag orifice location.
   g. Securely support relief valves and relief discharge lines.

D. Penetrations
1. Floor
   a. Provide sleeves on piping penetrations through floor slabs one pipe size larger than service piping, and extend sleeve 2" above finished floor.
2. Fire-Rated walls:
   a. Provide firestopping per Section 20 0700 - Mechanical Systems Firestopping.

3.3 USE POINT CONNECTIONS

A. Faucets
1. Install a reducing tee in distribution line with 1/2” outlet and fuse 1/2” diaphragm valve directly on tee outlet.
2. Connect outlet of valve to faucet with 3/8” polypropylene or PFA tubing.

3. Use shortest length of tubing as possible.

B. Equipment

1. install zero-static tee diaphragm valve on distribution line with outlet size indicated on distribution drawing
2. Install piping per size from valve to equipment.
3. Install Restriction Orifice if indicated on drawing.
   a. Use concentric plate in vertical lines.
   b. Use eccentric plate in horizontal lines.

3.4 TESTING

A. Inspection

1. Visually inspect all joints and verify that they comply with manufacturer's criteria for a properly formed joint.
2. For joints fused by machines that generate labels, verify that each joint has label.
3. Check diaphragm valve bonnet bolts for correct torque.

B. Hydrotest

1. Execute all pressure testing safely.
   a. Do not pressurize plastic piping with gas.
   b. Isolate equipment or instrumentation that cannot to be exposed to test pressure.
   c. Notify personnel with access to system that testing is to take place. Tag each use point to indicate that valve is not to be used.
   d. Ensure that air is completely vented from system to avoid a hazardous condition.
   e. Pressurize system gradually.
   f. Provide controls to prevent pressure from exceeding specified test pressure.
2. Ensure that cleanliness of system is not compromised.
   a. Provide water for testing and flushing that has quality equal to or better then service water.
   b. When performing preliminary testing of sections of system, after test is complete flush all water out of system and ensure that it drains completely. Close all openings in system after draining.
3. Execute final acceptance test on completed piping system.
   a. Do not insulate or conceal piping until testing is complete.
   b. Test system in sections or as a whole, but all joints need to be covered in test.
   c. Ensure that air is completely vented from system.
   d. Pressurize gradually and hold system at 100 psig for 4 h. An initial pressure decrease will occur due to pipe elongation after pressurization. After 4 h, pressure loss will stabilize, and pressure must then hold at test pressure without a loss of 1% over period of one hour to pass test.
   e. Monitor pressure with gauge located near bottom of system that is readable to at least plus or minus 1 psi.
   f. Note if pressure drops more than 1% over test period and determine source of leakage.
      1). Cut out and reinstall defective joints.
      2). Hand tighten wing nuts on sanitary clamps if required. If leakage continues, install new gasket. Do not tighten using tools.
      3). Retest.
4. Provide written certification that includes identification of portion of system tested, date, time, test criteria, test medium and pressure, duration, and name and title of person responsible for test.

3.5 SANITIZING/FLUSHING

A. General

1. Perform sanitization after inspection, documentation, and acceptance of system. If chemical sanitation is not required then this procedure will be used for flushing, without addition of sanitant.
2. Prior to sanitization, slowly fill system with water while venting air from system. Continue to check that all air has been vented after water is recirculating.
3. Adjust any pressure regulators to their preliminary setpoints.
4. Perform sanitization immediately prior to placing system in operation and coordinate with Laboratory's representative.
5. Safety:
   a. Follow manufacturer's safety recommendations for handling of chemicals.
   b. Disconnect power to UV lights prior to sanitization.
   c. Provide controls to ensure that system remains within pre-established sanitization conditions and that system pressure does not exceed Design Conditions in Part 1.5 above.
   d. Ensure that proper chemicals are used and that they are handled safely.
   e. Notify personnel with access to system that sanitation is being performed. Prior to cleaning, tag each use point to indicate that valve is not to be used.
6. Provide all equipment, fittings, and supplies necessary to execute sanitization.
7. Prepare a procedure which identifies:
   a. Recirculation circuit(s) and sampling points.
   b. Measures required to confine sanitizing solution.
   c. Step-by-step procedure (including any modifications to piping or controls).
   d. Sign-off matrix.
8. Isolate equipment or instrumentation that is not to be exposed to sanitant.
   a. Bypass ion exchange beds.
   b. Turn off UV lights.
   c. Record all changes made to system that are required to execute test.
9. Record execution of procedure including Laboratory sign-off.

B. Procedure for hydrogen peroxide.

1. Makeup solution of 5% hydrogen peroxide with water. Water shall be equivalent to service water quality or deionized water (minimum 1 megohm) that has passed through a 1.0-micron filter.
2. Fill entire system with solution. All gas must be vented, and system set up for recirculation so that all parts will be exposed to solution.
3. Recirculate at flow rate of at least 3 fps. Draw samples at points of use and at other key sample points to confirm presence and concentration of peroxide.
4. Confirm that there is solution throughout system, and then continue to recirculate for at least 4 h. Draw off water for at least one minute at each use point.
5. After recirculation with solution flush system with product quality water for at least 45 minutes, rotating draw off from all use points.
6. Test water with solution residual test strips at key sample points to ensure less than 1 ppm is achieved.

7. Continue to flush for 30 minutes. Draw off water for at least 1 minute at each use point.
8. Return system to its original configuration. Verify that all modifications that were made to piping or controls were restored. Prepare system for normal operation.

End of Section

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SECTION 22 67 20.13

HIGH PURITY WATER SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies the system for production and distribution of High Purity Water (HPW).

B. Complete specification of the system is defined by:
   1). This Section
   2). Sections listed under Related Work below,
   3). Flow Diagrams on drawings P5.1.4
   4). Equipment layout on drawing P5.14 Pure Water System diagram.

1.2 SCOPE

A. Contractor's Scope of Work includes:
   1. Subcontracting with an acceptable water treatment equipment vendor (Vendor) and managing Vendor's scope of work and performance. Coordinating:
      a. Size of equipment and skids with delivery schedule to ensure that equipment can be moved into place.
      b. Production of drawing showing layout of equipment positioned in Laboratory's area.
      c. Identification of all field installation of piping and wiring interconnections required between Vendor's equipment.
   2. Installation of Vendor's equipment and providing utilities to equipment.
      a. Providing piping and wiring interconnections between Vendor equipment as required.
   3. Providing distribution piping.
   4. Coordination of startup and system Turnover with Laboratory to ensure system is always actively managed.

B. Vendor's Scope of Work includes furnishing:
   1. A complete system, as defined in this document.
   2. Detailed drawings and instructions to Contractor for installation for field piping and wiring interconnections required between Vendor's equipment and components.
   3. Documentation
   4. Sanitization of system
   5. On-site support checkout, startup, and testing
   6. Demonstration that system meets quality and operational requirements
   7. On-site training
   8. Operation of system until turnover to Laboratory

1.3 RELATED WORK

A. HPW system shall meet requirements of following Sections:
   1. Section 20 05 13 - Motors
   2. Section 20 05 14 - Variable Frequency Drive (VFD) System

3. Section 22 67 14.13 - Plastic Piping for High Purity Service

1.4 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including. General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.5 BASIS OF DESIGN

A. Vendor is responsible for providing system that consistently and reliably delivers water of the following quality to the supply of distribution loop piping.
   1. If Vendor believes that system design specified herein will not meet the quality standards, Vendor shall notify Engineer.

B. Water Quality Requirements
   1. System shall provide water meeting NCCLS/CAP Type II reagent water specification to points of use. Specification is:
      a. Resistivity: $\geq$ 1.0 megohm - cm at 25°C
      b. Silicate: $\leq$ 0.1 mg/l SiO_2
      c. Microbial: $\leq$ 1000 CFU/ml

C. Supply Water Quality
   1. Vendor is responsibility for confirming validity of supply water analysis and notifying Engineer if quality is significantly different than stated below.
   2. Minimum temperature of supply water: 40°F
   3. Minimum pressure of supply water: 30 psig
   4. Maximum pressure of supply water: 80 psig
   5. Water production system shall be designed to produce required water quality based on maximum values from following water supply analysis.

D. Capacity Requirements
   1. System shall produce 17 gpm of water of quality stated above.
   2. Individual equipment shall comply with capacity and efficiency requirements stated below.

E. Size Requirements
   1. Equipment shall be located in area shown on drawings referenced in Part 1.1. Location and sizes of equipment shown in those areas are preliminary.
   2. Contractor shall work with Vendor to determine equipment layout and submit an accurate drawing indicating positions of equipment in the area.
   3. Layout shall ensure:
      a. Selected equipment and skid sizes will be able to pass through available building opening and passageways, or must be delivered prior to completion of that area of building.
      b. Proper access to HPW equipment and instrumentation for operations and maintenance.
      c. Compatibility with floor drains shown on drawings.
      d. Clearance for removal of regularly replaced components (filter elements, UV lamps, etc.)
      e. Access to tank manway and components on top of tank.

F. Site Conditions
   1. System location: mechanical room
   2. Electrical classification: non-hazardous

1.6 DOCUMENTATION

A. The following documents shall be furnished as follows:

	Submit For Approval	Upon Delivery	Turn Over Package
Production flow rates; flows to drain	X		
Piping and Instrumentation Diagram (P&ID)	X	X	As built
Pump Curves with Operating Points	X		X
Utility Loads	X		X
Drawing of system in facility space	X		
Instructions for Rigging, Storage, and Anchoring		X	
Instructions for extended storage of system, if necessary		X	
Detailed Equipment drawings	X	X	X
Equipment List	X		X
Descriptions of equipment and components.	X		X
Instrument List	X		X
Instrument Cut sheets	X		X
I/O List	X	X	X
Calibration Certifications		X	X
Operational and control description and functions	X		
Functional Specification	X	X	As built
Loop Diagrams		X	X
Control Schematics		X	X
Control Panel wiring drawings		X	As built
Component Cut Sheets	X		X
PLC Program Printout and Disk File			As built
OIT Configuration		X	As built
Electrical single line diagrams	X	X	X
Schematic wiring diagrams		X	X
Electrical panel drawings		X	X
Sanitization Procedure	X	X	
Acceptance Test Procedures		X	
Acceptance Test Report			X

	Submit For Approval	Upon Delivery	Turn Over Package
Water sampling results			X
O & M Manuals		X	As built
Training Program Outline		X	
Service Agreement Proposal		X	

1.7 WATER TREATMENT EQUIPMENT VENDORS

A. Acceptable Vendors: Wigen Water Technologies, MarCor Purification, Siemens Water Technologies, Burt Process Equipment, Therma Corporation, Crossbow-Water or approved equal.

1.8 DELIVERY

A. Vendor shall provide complete instructions on handling, rigging, anchoring, and on-site reassembly with unit.

B. Vendor is responsible for packaging to ensure unit arrives undamaged and uncontaminated.
   1. Nozzles shall have covers which protect the face from damage and seal system from contamination.
   2. Parts shipped loose shall be boxed and properly identified with durable, waterproof shipping tags attached with stainless steel wire or plastic tie strips. Parts shall be match marked for easy reassembly at site.

1.9 WARRANTY

A. System components shall be warranted from defects in materials and workmanship by respective manufacturer for period of 1 yr from date of start-up or 18 months from date of shipment, whichever occurs first. Start-up shall be considered to begin from date system is producing water quality as stated above, and approved by Laboratory.

PART 2 - PRODUCTS

2.1 GENERAL

A. For equipment that is skid mounted:
   1. Size of skid must be compatible with building dimensions and/or delivery must be coordinated with construction schedule to ensure that skid can be moved into building and set in place.
   2. Skid size and dimension must be compatible with room layout.
   3. Skids shall conform to AISC Manual of Steel Construction.
   4. Skid construction shall comply with local and state code seismic requirements.
   5. Single connection for each utility and for drain shall be provided.
   6. Frame to be stainless steel or carbon steel with 2 coats epoxy paint.
   7. Frame shall adequately support system components at their operating weights.
   8. Surfaces that allow water to pool on part of frame are not permitted.
   9. Skids shall be designed so that they may be lifted by both forklift truck and overhead crane.
   10. Vendor shall inform contractor of field work required to assemble and interconnect skids.

2.2 HOT/COLD WATER MIXING VALVE

A. Description: Mixing valve shall require no external control input and consist of a manually set temperature setpoint. Valve shall be designed for minimal bleed through at low flow rates. Thermostatic element shall be chosen for design temperature setpoint below.

B. Acceptable Manufacturers: Armstrong RADA or approved equal

C. Design Condition

1.	Design outlet flow range:	5 to 15 gpm
2.	Maximum Pressure Loss at Designed Flow:	10 psig at 15 gpm
3.	Hot water inlet temp:	120°F
4.	Cold water inlet temp:	Variable 33-73°F
5.	Setpoint outlet temp:	70°F ± 5°F
6.	Inlet water pressure:	40 psig
7.	Materials of construction:	Bronze, Brass or Stainless Steel

2.3 CARTRIDGE FILTERS

A. Description: Cartridge filter housing with hydrophilic cartridges for water filtration.

B. Acceptable Manufacturers: Ametek, Pall, Millipore, Sartorius or approved equal

C. Design flow: as listed in schedule

D. Filter rating: 10 micron

E. Pressure Drop: 3 psi at design flow

F. Housing Pressure Rating: 125 psig

G. Pressure gauges shall be provided before and after unit.

H. Sample valve shall be provided after unit.

2.4 CARBON FILTER

A. Unit shall be comprised of a single carbon filter, complete with piping, fully automatic brass motor driven multi-port control valve, pressure gauges, sample valves and media. Unit shall be preassembled, prewired, and hydrostatically tested. Media shall be packaged separately.

B. Service flow: as listed in schedule

C. Design Criteria

1.	Flow Rate Criteria:	less than 7 gpm/ft^2 at design flow rate
2.	Backwash Flow Rate:	10 gpm/ft^2
3.	Fast Rinse Flow Rate:	5-10 gpm/ft^2
4.	Chlorine Removal:	0 ppm at carbon effluent
5.	Clean Bed Pressure Drop:	less than 5 psig at design flow rate

D. Mechanical

1. Vessel

a.	Material:	Fiberglass
b.	Pressure Rating/test:	100 psig/150 psig
c.	Temperature Rating:	120°F
d.	ASME Code Stamped:	No
e.	Internal distributors:	

1). Material: PVC or ABS
2). Inlet Distributor (Top): Top inlet baffle
3). Underdrain Distributor (Bottom): Hub radial with laterals

f. Access: ports in top head for control valve connection and media loading/removal.

2. Media: Acid washed Activated Carbon, Fine Gravel, Medium Gravel.
3. Piping:
   a. As per referenced pipe Section.
   b. Provide connections for sanitization.

E. Controls: Backwash frequency controlled by seven-day time clock. Operator shall have option to select day-of-week and time-of-day for backwash to occur.

F. Electrical: 120 VAC, single phase, 60 Hz

G. Pressure gauges shall be provided before and after unit.

H. Sample valve shall be provided after unit.

2.5 REVERSE OSMOSIS (RO) UNIT

A. RO unit shall be skid mounted, fully automatic, single pass system. Unit shall be preassembled, prewired, and hydrostatically and functionally tested.

B. Design Conditions
   1. Design flow: as listed in schedule
   2. Feedwater Temp: 70°F

C. Design Criteria
   1. Max Average Permeate Flux/Element: 18 gfd (Gallons/ft^2/day)
   2. System Recovery: 75%
   3. Minimum Salt Rejection: 96% at stated recovery
   4. RO Membranes:
      a. Type: Polyamide thin-film composite
      b. Manufacturer: Filmtec (Dow) or approved equal
      c. Minimum Salt Rejection: 98%

D. Instrumentation
   1. The following instruments shall be provided:
      a. Conductivity sensors on feed and permeate. TDS monitor is not permitted.
      b. Low pressure switch on feed
      c. Flow indicator on permeate
      d. Flow indicators on reject

E. Mechanical
   1. Frame:
      a. System shall be supported by epoxy-coated frame, and designed to provide easy access for servicing, maintenance, and monitoring of operation.
      b. Piping shall be neatly arranged and supported on frame.

c. Frame shall be designed for seismic zone indicated in Part 1.1 and shall offer maximum support and protection for system components.

2. RO Prefilter: 5 micron absolute, sized for max 3 psi pressure drop at maximum RO flow.
3. Valves:
   a. Automatic, pneumatically actuated, non-metallic, or stainless steel valve shall be provided in feed line. High pressure valves, including pump discharge throttling valve, reject throttling needle valve and reject recycle throttling needle valve shall be 316 stainless steel.
   b. Reject flush valve shall by-pass reject water around reject throttle valve.
   c. Sample valves shall be provided on feed, product, and reject pipe lines. Individual sample valve on product tubing of each pressure vessel shall be provided for analyzing system performance.
   d. Reject and reject recycle needle valves shall be mounted in close proximity to their respective flow rate indicators for ease of field adjustment.
4. Pressure gauges shall be furnished to monitor RO inlet pressure, pump suction pressure, membrane feed pressure, membrane reject pressure and RO product pressure.
5. Pressure Vessels:
   a. Manufacturer: Advanced Structures, Inc. or approved equal
   b. Material: FRP
   c. Rating: 400 psig
6. Piping:
   a. Piping shall be designed for minimal removal during membrane loading.
   b. Nozzles shall be provided for connection of temporary lines for cleaning and sanitizing RO membranes and vessels.
7. Material and connections:
   a. Feed and Reject Pipe: Per referenced pipe section
   b. High Pressure Pipe: 316 L stainless steel tubing
   c. Product Piping: Per referenced pipe section
   d. Pump: 316 stainless steel

F. Control System: Microprocessor or PLC based control system shall monitor and control operation of system and communicate with pretreatment equipment and distribution tank level as required. Skid mounted control panel shall house control system, operator interface controls, solenoids, IEC motor starter(s), step down transformer, high voltage disconnect. Control system shall be fully programmed and integrity tested at factory prior to shipment.
   1. Panel shall include:
      a. Lights, pushbuttons, and switches for status and control of system
      b. Conductivity monitor for feed and permeate
      c. Elapsed run time indicator
      d. Alarm horn
      e. System power switch
      f. Nameplates for device identification
      g. Automatic reject flush indicator and controls
   2. Alarm conditions shall Include:
      a. Low feed pressure
      b. High and High High, permeate conductivity
   3. Unit Shutdowns include:
      a. Low feed pressure

b. Pretreatment filters in backwash
c. Product storage tank full
d. High High permeate conductivity

4. Functional Specification
   a. Complete functional specification shall be provided which describes:
      1). operation of unit
      2). control loops
      3). interlocks
      4). alarms
      5). startup/shutdown sequences
      6). security

G. Electrical
   1. RO unit shall have a single connection for 480 V, 3 phase power. Transformers for devices requiring other voltage shall be provided integral to skid.

2.6 CARTRIDGE FILTERS - HIGH PURITY

A. Description: T-style cartridge filter housing with hydrophilic, pharmaceutical grade cartridges for water filtration

B. Acceptable Manufacturers: Pall, Millipore, Sartorius, or approved equal

C. Design Conditions
   1. Filter F-3
      a. Design flow: as listed in schedule
      b. Filter rating: 0.2 micron absolute
      c. Pressure Drop: 2 psi at design flow

D. Mechanical:
   1. Housing Material: 316 stainless steel, 25 Ra
   2. Housing Pressure Rating: 145 psig
   3. Gasket Type: FDA approved Silicone
   4. Housing Configuration: T-style
   5. Connection Type: Tri-clamp
   6. Sample valves: Inlet and outlet
   7. Drain valve: 1/2 inch

2.7 ULTRAVIOLET LIGHTS

A. Description: In-line Ultraviolet Lights

B. Acceptable Manufacturers: Aquionics, Aquafine, Ideal Horizons

C. UV-1 Design Conditions
   1. Service: Bacterial Reduction
   2. Wavelength: 254 nm
   3. Dosage: 30,000 microwatt-sec/cm^2 after 9,000 hours
   4. Microbacterial (E-coli) reduction: 99.9%

5. Design Flow Rate: as listed in schedule

D. Materials
1. Wetted surfaces: 316L stainless steel electropolished to a surface finish of 15 Ra and passivated.

E. Connections shall be flange Tri-clamp.

F. Accessories: 2 "S" pattern light traps, 1 on inlet and 1 on outlet.

G. Instrumentation
1. Temperature sensor with shut down interlock, local alarm, dry contacts.
2. UV intensity meter with local alarm and dry contacts.
3. LED operating indicators for each UV lamp.
4. Elapsed running time meter.
5. Remote start/stop capability.

H. Electrical: 120 VAC; single phase, 60 Hz

2.8 STORAGE TANK

A. General: Provide tank as per this specification.

B. Description: polyethylene, cylindrical, atmospheric, closed top tank with flanged and covered manway.

C. Acceptable Manufacturers: Snyder Tanks, Polyprocessing, Chemtainer, or approved equal

D. Capacity: as listed in schedule.

E. Tank to be one piece, seamless construction of high density linear polyethylene.

F. Polyethylene to be FDA approved for food contact as per 21 CFR 177.1520. Resin complies with ASTM D-1998.

G. Design for at least 1.9 specific gravity. Temperature is 60 to 80°F.

H. Tank shall be air-tight

I. Cone or dish bottom to be totally drainable.

J. Indoor location

K. Dished top head

L. Epoxy coated (2 coats) steel, or plastic support, so that bottom tank nozzle is at least 18" off of floor.

M. Nozzles:
1. Nozzles shall be welded inside and outside.
2. Nozzles shall all be flanged and gusseted.
3. A standard lid is unacceptable. Manway shall be flanged with gasketed, bolted cover.
4. Minimum size of nozzles is as per following schedule. Vendor is responsible to ensure adequate number and size of nozzles

5. Schedule

LOCATION	SERVICE	SIZE	CONNECTION	NOTES
Top	Manway	16”min.	flange	Replace standard access port with a flanged nozzle
Top Center	Sprayball	2"	flange	
Top	Inlet	1"	flange	
Top	Vent	1.5"	flange	
Top	Breather	2"	flange	
Top	Loop return	1-1/2”	flange	
Top	Level transmitter	By Vendor	flange	top or bottom depending on level transmitter
Bottom center	Outlet	1.5"	flange	Provide Vortex Breaker

N. Quality Control :
1. Vendor shall have active quality control program.
2. Tank fabrication and all welds shall be inspected, and inspection shall be documented.
3. Testing shall conform to ASTM D-1998.
4. Tank shall be kept clean during and after fabrication consistent with use for high purity service.

2.9 STORAGE TANK PRESSURE/VACUUM RELIEF

A. Vendor shall provide pressure and vacuum relief to protect tank in the event of blockage of vent filter or overfilling due to failure of level controls.

B. Vendor shall ensure that relieving device does not open during normal operation, but opens adequately under excessive vacuum or pressure to protect tank.

C. Breather Valve
1. Description: Breather vent valve with pressure and vacuum relief
2. Acceptable Manufacturers: Protectoseal or approved equal
3. Design Conditions
   a. Pressure relief setting 12” water
   b. Vacuum relief setting 12” water
   c. Size: 2”
4. Mechanical
   a. Material: Stainless steel; Teflon seat
   b. Connections
      1). Tank: 2" Flange, 150# ANSI
      2). Pressure out 2" Flange, 150# ANSI
      3). Vacuum in: open

2.10 STORAGE TANK SPRAY BALL ASSEMBLY

A. Description: Static spray ball with connecting piping

B. Sprayball
1. Acceptable Manufacturers: Sanimatic or approved equal

2. Design Conditions: 30 gpm at 20 psi
3. Material: 316L stainless steel with 25 Ra finish; Teflon
4. Connection: Slip joint with stainless steel pin
5. Pattern: 180 degrees upward; uniform coverage
6. Features: Self draining

C. Piping
1. Specification: Piping as per referenced section.
2. Configuration: Piping to suspend ball at location[s] that provide complete and uniform coverage spray to top of tank. Piping to attach to tank flange. Sprayball used for sanitization of tank by providing temporary connection from pump connection.

2.11 STORAGE TANK VENT FILTER

A. Description: Cartridge filter housing and hydrophobic sterile filter element for vent filtration.

B. Acceptable Manufacturers: Pall, Millipore, Sartorius, or approved equal

C. Design Conditions
1. Rating: 0.2 micron absolute
2. Pressure Drop: 0.2 psid maximum at 8 scfm

D. Filter Housing:
1. Material: Polypropylene
2. Pressure Rating: 50 psig minimum
3. Gasket Material: Silicone
4. Configuration: T-style

E. Filter Element:
1. Quantity: per Vendor
2. Grade: Pharmaceutical, 0.2 micron absolute, hydrophobic
3. Material: PVDF/Polypropylene

2.12 LOOP COOLER

A. Description: Sanitary, double tube sheet, shell and tube heat exchanger.
1. Unit shall be installed on slip steam off high purity water loop as shown in drawings.
2. Shell side shall be chilled water.
3. Control shall be manual.

B. Acceptable manufacturer: Exergy Series 35, double tubesheet, Model 01095-5, or approved equal

C. Following instrumentation shall be provided:
1. Temperature gauge on chilled water return line.
2. Sanitary temperature gauge on high purity water outlet pipe.
3. Pressure relief valve (1/2") on chilled water line at exchanger for thermal expansion relief.
4. Globe valve on outlet of chilled water.

2.13 DISTRIBUTION PUMPS

A. Vertical, multistage, stainless steel centrifugal, Grundfos CRN or approved equal

B. Grundfos model CRN-series

C. Design rating: as listed in schedule.

D. Surfaces in contact with water shall be 316 stainless steel.

E. Nozzles shall be Triclamp.

F. Seal shall be a single bellows mechanical seal with a carbon stationary face and a tungsten carbide rotation face.

G. Motor shall be TEFC, 460 V, 3 phase, VFD compatible

H. VFDs shall be provided for motors by HPW equipment Vendor.

2.14 MIXED BED DI COLUMNS - EXCHANGABLE

A. Description: Exchangeable mixed resin ion exchange beds arranged in series. Beds contain 60% anion/40% cation resin mixture, premium grade.

1. Design Criteria

a.	Volumetric Flow Rate:	Less than 10 gpm/ft^3 at design flow
b.	Cation Resin:	Strong acid, hydrogen form
c.	Anion Resin:	Strong base type 1, hydroxyl form
d.	Resin Capacity:	15,000 grams/ft^3

B. Mechanical

1.	Vessels:	fiberglass reinforced plastic (FRP) with vinyl ester lining and connections
2.	Vessel Rating:	
3.	Hoses:	polypropylene
4.	Piping:	as per referenced pipe Section

C. Accessories

1. Polypropylene hoses to each bed
2. conductivity indicator after first set of beds
3. Pressure gauges shall be provided before and after assembly of beds
4. Sample valve shall be provided after assembly of beds

2.15 INSTRUMENTATION

A. General

1). Instrumentation shall be provided to enable reliable, safe, and efficient operation of the system, and to meet the functional requirements of this specification.

2. Instrumentation shown on the drawings identified in Part 1.1 and in this specification shall be provided.

3. Instruments shall be appropriate for water quality level.

a. Instrument in contract with water downstream of the RO unit shall be of sanitary design. Pressure sensors shall have diaphragm seals.

4. Vendor shall ensure instruments are properly calibrated.

B. Production System

1. Instruments integral to production system shall provide the required functionality with a high level of reliability.
2. Hardness monitor shall be Hach SP510 or approved equal.
3. Chlorine monitor shall be Hach CL17, ATI A15, or approved equal.

C. Distribution system:

1. Resistivity and temperature transmitters shall be Thornton or approved equal.
   a. Vendor shall provide calibration certification of installed unit.
   b. Sensors for conductivity/resistivity shall be installed in run of a horizontal tee with flow exiting the upward branch.
2. Flow meters shall be sanitary turbine meters, 316 stainless steel, 3A rating; Flow Technology, Inc., Thornton, Hoffer Flow Controls, or approved equal;
   a. Straight pipe upstream and downstream of flow meters as specified by manufacturer
3. TOC monitor shall be Thornton or Anatel or approved equal.
   a. Vendor shall provide calibration certification of installed unit.
4. Tank level transmitter shall provide continuous measurement of water level.
5. Diaphragm seals shall be provided for all gauges and pressure transmitters on piping and equipment in distribution system. Alternatively, pressure gauges with 3A rating can be used.
6. Thermowells shall be 316 stainless steel, 3A rated.
7. Pressure regulators and backpressure regulators shall be installed with at least 10 pipe diameters of straight pipe upstream and downstream of regulator.
8. Self contained backpressure regulator and gauge shall be provided on the end of the return line of the distribution loop.
   a). Specification as per referenced piping section
   b). Adjustable pressure range 25 to 35 psig.
9. Pressure Gauges shall have minimum 3.5” face.

2.16 CONTROL SYSTEM

A. General

1. Controls shall be provided to enable reliable, safe, and efficient operation of the system, and to meet the functional requirements of this specification.
2. Vendor shall provide:
   a. A dedicated control system to monitor and control the entire system
   b. Design of the control system, hardware, and software.
   c. Controls and instrumentation required to ensure proper operation of the equipment and to consistently and reliably produce and maintain the required water quality.
   d. Programming to accomplish the required functions. Programming shall be systematically tested, including challenge testing, and testing shall be documented.
   e. A functional Specification that completely describes the operation of the system and specifies the acceptable ranges for operating parameters.
3. This specification is written for systems that have a dedicated PLC on RO unit; and would require second PLC for distribution system. Optionally, a single PLC that would control entire system would be acceptable and preferable.

B. Hardware
   1. PLC shall be an Allen Bradley MicroLogix or CompactLogix.
   2. HMI shall be Allen Bradley Panelview 550 Plus.
   3. System shall have 20% spare processing capacity and space for cards that would provide an additional 20% I/O.

C. Functionality
   1. System shall automatically:
      a. Operate the production system
      b. Start and stop of flow from the production system into the storage tank based on tank level.
      c. Stop the flow from the production system into the storage tank if the resistivity falls below the acceptable value or if key production operating parameters are out of range.
      d. Adjust the speed of distribution pump to maintain constant flow rate at end of loop.
         1). The loop has one primary pump and one standby pump.
      e. Stop the distribution pump if tank is below Low Low level.
   2. System shall continuously monitor and provide alarms for:
      a. Hardness level in supply to RO
      b. Chlorine concentration in supply to RO
      c. Tank levels
      d. Discrete alarm signals from RO, UV lights, and other equipment to ensure safe and proper operation of those units.
      e. Resistivity of water from the production system that is supplied to storage tank
      f. Distribution loop:
         1). Resistivity, on supply line
         2). Resistivity, flow, temperature on return.
         3). TOC
      g. Distribution pump running
      h. Faults from distribution pump VFD.
      i. Status of distribution pump.
   3. Control system shall provide:
      a. One discrete general fault output for connection to the BAS system corresponding to any alarm condition.
      b. An Alarm List.
      c. Capability of assigning multiple levels of alarms for all analog monitored parameters: low low, low, high, high high.
      d. Capability of providing a time delay for each alarm.
      e. Password protected, multilevel security to prevent change of primary operating parameters by unauthorized personnel.
   4. Alarms
      a. Vendor shall specify appropriate operating ranges and alarm setpoints for the production system.
      b. Alarm for the distribution system and preliminary setpoints shall be as follows:
         1). Storage Tank Level
            a). High High - Approx. 95% capacity: Provide Alarm.
            b). Full - Approx. 90% capacity

c). Add - Approx. 75% capacity

d). Low Low alarm - Approx. 50% capacity: Provide Advisory message. This level indicates that makeup is inadequate.

e). Low - Approx. 5% capacity: Shut down distribution pumps and provide alarm. Pumps shall not start under Low Low level conditions.

2). Resistivity

a). Low: Fixture Alarm adjustable megohm

b). Low Low: Adjustable megohm

3). Temperature

a). High: 80 °F Advisory

b). High High: 85 °F Alarm

4). Flow in loop return:

a). High: 40 gpm Alarm and shutdown pumps

b). Low: 22 gpm Advisory

c). Low Low: 15 gpm Alarm

5). Alarms shall only be active when pump has been in Automatic Mode for at least 1 minute.

5. Operator Interface (Panelview) shall:

a. Provide graphical displays that show process in flow diagram format

1). summary screen[s]

2). Several individual screens, dividing the system into logical parts, sufficient to clearly and logically display content.

b. Display:

1). all monitored parameters on the graphics

2). operation status of equipment

3). Active Alarms.

4). Alarm History.

D. Panels

1. NEMA 12 panel(s) shall be provided to contain controls, solenoids, operator interface, motor starters, step down transformers, and other devices required for system.
2. Panels shall be designed and listed in accordance with UL 508A.
3. Transmitters to be mounted in panels where feasible.
4. Power for transmitters and instrumentation shall be provided from panel.
5. Local horn and beacon for alarm conditions shall be provided. Provide alarm silence button.
6. Panels shall provide 20% minimum spare capacity of space, PLC chassis space, wireway space, and terminal blocks to allow for future expansion by adding I/O cards and associated cabling.

2.17 ELECTRICAL POWER

A. Vendor shall provide all panels, devices, wiring, local disconnects, VFDs and motor controls for the system.

1. A separate low voltage panel shall be provided for the PLC and HMI.
2. Panels shall be designed and listed in accordance with UL 508A.
3. An E-stop shall be provided.
4. Electrical components and installation shall conform to the NEC.
5. Equipment and installation shall conform to the latest requirements or state and local authorities having jurisdiction.

6. UL labeled equipment shall be provided to the full extent that UL labels are applicable.
7. Wiring shall comply with methods approved in NFPA 79.

B. Motors
1. NEMA Premier efficiency as per NEMA MG. 1-2003.
2. Service factor of 1.2 Shall not operate in service factor
3. TEFC
4. Conform to requirements of NEMA, IEEE, NSI, and NEC standards and shall be listed by UL for service specified.

C. Drops will be provided, under the electrical contractor's scope of work, at the following locations:
1. Individual 110 VAC/1 ph/60 Hz drops to equipment prior to the reverse osmosis unit.
2. One 480 VAC/3 ph/60 Hz drop to panel on the reverse osmosis unit.
3. One drop 480 VAC/3 ph/60 Hz to a distribution system equipment panel.
4. Vendor shall provide for distribution of power from these panels to accommodate all of Vendor's needs.
   a. Vendor will be responsible for transforming power as required.
   b. Vendor shall provide detailed instructions to Contractor covering any field wiring between Vendor equipment.
   c. Vendor shall provide local disconnects.

PART 3 - EXECUTION

3.1 CONTRACTOR RESPONSIBILITIES

A. Coordinate delivery of tank and skids with building construction to ensure that tank can be moved into building and set in place.

B. Inspect delivered equipment and components for evidence of damage or contamination

C. Rig, handle, store, set, and anchor equipment as per Vendor's recommendations and in manner that prevents impact damage and excessive stress.

D. Maintain a high level of cleanliness during handling and installation.
1. Prior to starting work, identify areas that will be used for storage and fabrication, and take measures to prevent contamination from adjoining areas.
2. Keep openings on assemblies sealed during fabrication to prevent contamination prior to final installation.

E. Provide housekeeping pads as indicated on the drawings identified in Part 1.1.
1. Determine final size of pads based on approved Vendor submittal drawings.

F. Install equipment level and plumb.

G. Interconnect Vendor equipment as required
1. Install HPW piping in compliance with specification in "Related Work"
2. Connect utilities.

H. Ensure that the system is ready for safe startup.

I. Provide tagging for equipment, piping, and valves.

J. Coordinate startup, balancing, testing and turnover of system with Laboratory and Vendor.
   1. After the system is fully operational, oversight is required to maintain acceptable water conditions.
   2. Make arrangements to enable Vendor to monitor and manage the operation until the Laboratory is able to take full responsibility for the system.

3.2 VENDOR RESPONSIBILITIES

A. Provide a representative responsible for on-site activities:
   1. Verify that system is ready for startup.
      a. Inspect installation, interconnections, utility connections, vents, etc
      b. Load media and filter elements as required.
      c. Conduct pre-startup check-out.
   2. Startup and test system.
      a. Verify proper operation in all operating modes.
      b. Adjust operation of equipment and controls to meet operational, water quality, and safety requirements, and update documentation as required.
      c. Test and balance distribution system and achieve stable operation at specified flow and pressure conditions.
      d. Adjust self contained backpressure regulator at end of distribution loop to maintain pressure at its upstream pressure gauge at the design setpoint value.
         1). Verify system flows are as per design values
   3. Sanitize system as per procedure.
   4. Demonstrate to the Laboratory or to the Commissioning Agent that system operates in accordance with requirements of this specification and per approved submittal documentation.
      a. Provide procedures that systematically verify that system operates as designed.
         1). Identification of acceptable ranges for all operating parameters.
      b. Draw samples from at least 4 locations on the distribution loop and provide the results of analysis indicating that the water meets the bacteria level requirement.
         1). Arrange for the bacterial analysis to be performed by an independent testing laboratory, using standard methods, compliant with the requirements of the water quality standard in Part 1.5.
      c. Calibrate resistivity and TOC monitors and provide calibration certification.
   5. Maintain operational oversight of system until Laboratory's organization is able to assume responsibility for operation.
   6. Provide Turn Over documentation as identified in Part 1.
      a. Documents shall include the final operational setpoints and information.

7. Provide training for Laboratory
    a. Provide a program that covers overview, operator training, and maintenance training.
    b. Operations training shall include:
        1). Start-up procedure.
        2). Shutdown procedure.
        3). Emergency operations.
        4). Safety procedures and hazards.
        5). Alarm conditions and actions,
        6). Parameter adjustments
        7). Security

End of Section

SECTION 22 90 00

COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description

B. Responsibilities

C. Related Work

D. Test Equipment

E. Submittals

F. Startup

G. Contractor Tests

H. Functional Performance Tests

I. Testing Documentation, Non-Conformance and Approvals

J. Operation and Maintenance Manuals

K. Training of Owner Personnel

L. Deferred Testing

M. Written Work Products

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 22 responsibilities in the commissioning process.

B. The systems to be commissioned are listed in Section 01 91 00.

C. Commissioning requires the participation of Division 22 to ensure all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 22 Contractor shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CxA, and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.3 RESPONSIBILITIES

A. Plumbing, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the plumbing, controls and TAB contractors of Division 22 are as follows (all references apply to commissioned equipment only):

1. Construction and Acceptance Phases

   a. Include and itemize the cost of commissioning in the contract price.

   b. In each purchase order or subcontract written, include requirements for submittal data, commissioning documentation, O&M data and training.

c. Attend a commissioning scoping meeting and other meetings necessary to facilitate the commissioning process.

d. Contractors shall provide the CxA with normal cut sheets and shop drawing submittals of commissioned equipment.

e. Provide additional requested documentation, prior to normal O&M manual submittals, to the CxA for development of start-up and functional testing procedures.

   1) Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any Owner-contracted tests, pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.

   2) The Commissioning Agent may request further documentation necessary for the commissioning process.

   3) This data request may be made prior to normal submittals.

f. Provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, to the CxA for review and approval.

g. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

h. Provide limited assistance to the CxA in preparing the specific functional performance test procedures. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

i. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists from the CxA for all commissioned equipment. Submit to CxA for review and approval prior to startup. Refer to Section 01 91 00 for further details on start-up plan preparation.

j. During the startup and initial checkout process, execute the plumbing-related portions of the prefunctional checklists for all commissioned equipment.

k. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.

l. Address current punch list items before functional testing. Water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective water-related systems.

m. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

n. Provide skilled technicians to perform functional performance testing under the direction of the CxA for specified equipment in Section 01 91 00. Assist the CxA in interpreting the monitoring data as necessary. Provide trending reports and graphs as may be required or available for systems being tested.

o. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, GC and Design Engineer and retest the equipment.

p. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

q. During construction, maintain as-built red-line drawings for all drawings. Update after completion of commissioning (excluding deferred testing).

r. Provide training of the Owner's operating staff using expert qualified personnel, as specified.

s. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

2. Warranty Period

a. Execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications.

b. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

B. Plumbing Contractor. The responsibilities of the Plumbing Contractor, during construction and acceptance phases in addition to those listed in (A) are:

1. Provide startup for all Plumbing equipment, except for the building automation control system.

2. Assist and cooperate with the TAB contractor and CxA by:

a. Putting all Plumbing equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.

b. Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.

3. Install a P/T plug at each water sensor that is an input point to the control system.

4. Prepare a preliminary schedule for Division 22 pipe system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CxA. Update the schedule as appropriate.

5. Notify the GC or CxA depending on protocol, when pipe system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the GC or CxA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CxA has the scheduling information needed to efficiently execute the commissioning process.

C. Controls Contractor. The commissioning responsibilities of the Controls Contractor, during construction and acceptance phases in addition to those listed in (A) are to be identical to those outlined in 23 90 00.

D. TAB Contractor. The duties of the TAB Contractor, in addition to those listed in (A), are to be identical to those listed in 23 90 00.

1.4 RELATED WORK

A. Refer to Section 01 91 00 for a listing of all sections where commissioning requirements are found.

B. Refer to Section 01 91 00 for systems to be commissioned.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 01 91 00 for additional Division 22 requirements.

PART 3 - EXECUTION

3.1 SUBMITTALS

A. The Contractor shall provide submittal documentation relative to commissioning as required in this section and Section 01 91 00.

3.2 STARTUP

A. The Plumbing and Controls Contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities List in this section and in Section 01 91 00. The Contractor has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CxA. Beginning system testing before full completion, does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.3 CONTRACTOR TESTS

A. Subcontractors/installers shall forward to the Commissioning Authority, through the GC, a list and schedule of specified contractor tests. The tests shall include at least the following:

Section 22 11 18	Water Distribution System	3.9 3.10 3.11	Testing Disinfection Biological Tests

B. Unless specified otherwise, provide a minimum one week prior notice to the Commissioning Authority through the GC for each specified Contractors' test.

C. Submit Contractors' test reports to the Commissioning Authority, through the GC within one week of the successful completion of each test. Contractors shall document and issue a test report for each required test. The test report shall contain all information required by the respective specification section including the test date, start time, stop time, test duration, initial values, final values, expected result, and acceptable test values (per individual specification sections). The person(s) conducting each test and the local code authority (if applicable) shall sign and date each test report indicating that the test has been successfully completed and the results are within acceptable parameters.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. Refer to Section 01 91 00 for a list of systems to be commissioned.

3.5 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

A. Refer to Section 01 91 00 for specific details on non-conformance issues relating to prefunctional checklists and tests.

B. Refer to Section 01 91 00 for issues relating to functional performance tests.

3.6 OPERATION AND MAINTENANCE (O&M) MANUALS

A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications.

B. The Contractor shall compile and prepare documentation for all equipment and systems covered in Division 22 and deliver this documentation to the GC for inclusion in the O&M manuals, according to this section and Section 01 91 00, prior to the training of Owner personnel.

C. The CxA shall receive an electronic copy of the O&M manuals for review.

D. Review and Approvals. Review of the commissioning related sections of the O&M manuals shall be made by the Owner Advocate and by the CxA. Refer to Section 01 91 00 for details.

3.7 TRAINING OF OWNER PERSONNEL

A. The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 00 for additional details.

B. The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment or systems. Refer to Section 01 91 00 for additional details.

C. Plumbing Contractor. The Plumbing Contractor shall have the following training responsibilities:

1. Provide the CxA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00.
2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of mechanical equipment including, but not limited to, pumps, hot water heaters, controls and water treatment systems, etc.
3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, power failure, etc.
4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
6. The Controls Contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
7. The training sessions shall follow the outline in the table of contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
8. Training shall include:
   a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
   c. Discussion of relevant health and safety issues and concerns.
   d. Discussion of warranties and guarantees.
   e. Common troubleshooting problems and solutions.
   f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
   g. Discussion of any peculiarities of equipment installation or operation.
   h. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.
9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
10. The Plumbing Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not *controlled* by the central control system.

11. Training shall occur after functional testing is complete, unless approved otherwise by the Owner.

3.8 DEFERRED TESTING

A. Refer to Section 01 91 00 for requirements of deferred testing.

3.9 WRITTEN WORK PRODUCTS

A. Written work products of Contractors will consist of the start-up and initial checkout plan described in Section 01 91 00 and the filled out start-up, initial checkout and prefunctional checklists.

END OF SECTION

SECTION 23 05 50

VIBRATION ISOLATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 05 29 - Mechanical Supporting Devices

B. Section 23 33 14 - Ductwork Specialties (Duct Flexible Connections)

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESIGN CRITERIA

A. Isolate all motor driven mechanical equipment, unless otherwise noted, from building structure, and from systems that they serve, to prevent equipment vibrations from being transmitted to structure. Unless specifically indicated, follow the latest edition of ASHRAE Application Handbook - Sound and Vibration Control, or manufacturer's recommendations for isolator selection whichever is more stringent.

B. Select and locate isolators to produce uniform loading and deflection. Use minimum of 4 isolators to support each piece of equipment.

C. Select vibration isolation devices based on the lowest operating speed of equipment.

D. Vibration Criteria:

1. All rotating equipment shall operate at speeds less than 80% of their true critical speed. Unless otherwise required, equipment shall be balanced according to recommendations given in the following schedules.
2. Vertical vibration of rotating equipment shall not be greater than levels indicated. Vibration shall be measured on equipment. If equipment has inertia base, allowable vibration level is reduced by ratio of equipment weight alone to equipment weight plus inertia base weight.

Equipment Speed rpm	Maximum Allowable Vibration Displacement Peak-to-Peak (mil)
100 to 200	10
200 to 300	6
300 to 600	4
600 to 1000	3
1000 or 2000	2
over 2000	1

1.4 SUBMITTALS

A. Submit Shop Drawings including, but not limited to, the following:

1. Manufacturer's name

2. Isolator type and model number
3. Materials of construction and finish
4. Dimensional data
5. Load ratings (lbs)
6. Isolator free and operating heights
7. Static deflections
8. Isolation efficiency based on lowest operating speed
9. All other appropriate data

1.5 SUPERVISION, INSPECTION AND CERTIFICATION

A. Vibration isolation manufacturer or qualified representative shall provide supervision to assure correct installation and adjustment of isolators. Upon completion of installation and after system is put into operation, manufacturer or manufacturer's representative, shall make final inspection, adjustment, and submit report to Engineer in writing, certifying correctness of installation and compliance with Specifications.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials used shall retain their isolation characteristics for life of equipment served. Elastomeric materials shall comply with ASTM D2240 and shall be oil-resistant industrial grade neoprene.

B. Isolators shall be treated to resist corrosion.

C. Isolation devices subject to weather shall have either hot-dip or cold-dip galvanized, cadmium plated, or neoprene coated finish after fabrication and be furnished with limit stops to resist wind.

D. Vibration isolator springs shall have minimum additional travel to solid equal to 50% of rated deflection.

E. Ratio of lateral to vertical stiffness of vibration isolators shall not be less than 0.8 or greater than 2.0.

F. Coordinate selection of devices with isolator and equipment manufacturer.

2.2 MANUFACTURERS

A. Mason Industries, Amber/Booth Co., Aeroflex-VMC-Korfund. Vibration Eliminator, Vibro-Acoustics, or Kinetics equal to manufacturer's model listed, except flexible pipe connections.

B. Mason, Metraflex, Proco, Twin City Hose or Engineered Flexible Products (EFP) for flexible pipe connections.

2.3 TYPE 1 MOUNTS (NEOPRENE PAD)

A. Mason Type Super W, neoprene waffle pads, 50 durometer. Select number and size of pads as required to accept equipment operating weight evenly.

2.4 TYPE 2 MOUNTS (NEOPRENE PAD)

A. Mason Type ND or rails Type DNR, double deflection neoprene mounts with cast-in metal inserts for bolting to equipment.

B. Both surfaces shall be rib molded for skid resistance. On equipment such as small vent sets and close coupled pumps, steel rails shall be used above mountings to compensate for overhang.

2.5 TYPE 3 MOUNTS (UNHOUSED SPRING WITH NEOPRENE)

A. Mason Type SLF, combination spring and neoprene with rib molded base. Spring type isolators shall be free standing and laterally stable without any housing and complete with 1/4" neoprene acoustical friction pads between baseplate and support.

B. Mountings shall have leveling bolts rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of compressed height of spring at rated load.

2.6 TYPE 4 MOUNTS (RESTRAINED SPRING WITH NEOPRENE)

A. Mason Type SLR, combination spring and neoprene with rib molded base similar to Type 3 above, but shall have housing that includes vertical limit stops to prevent spring extension when weight is removed.

B. Installed and operating heights shall be the same. Maintain minimum clearance of 1/2" around restraining bolts and between housing and spring so as not to interfere with spring action. Limit stops shall be out of contact during normal operations. Use height saving brackets.

2.7 TYPE S BASES (STEEL BASE)

A. Mason Type WF, structural steel bases, rectangular in shape for all equipment other than centrifugal refrigeration machines and pump bases which may be "T" or "L" shaped. Pump bases for split case pumps shall include supports for suction and discharge base ells. Perimeter members shall be beams with minimum depth equal to 1/10 of longest base dimension, but not less than 4". Beam depth need not exceed 14" provided that deflection and misalignment is kept within acceptable limits as determined by manufacturer. Employ height saving brackets in all mounting locations to provide base clearance of at least 1" above floor or housekeeping pad.

2.8 TYPE I BASES (INERTIA BASE)

A. Mason Type K, or BMK rectangular or T shaped structural beam or channel concrete forms for floating foundations. Bases for split case pumps shall be large enough to provide support for suction and discharge base ells. Base depth need not exceed 12" unless specifically recommended by base manufacturer for mass, rigidity or component alignment. Base depth shall be a minimum of 1/10 of longest base dimension, but not less than 6". Forms shall include concrete reinforcement bars welded in place running both ways. Furnish forms with drilled steel members with sleeves welded below holes to receive equipment anchor bolts where anchor bolts fall in concrete locations. Employ height saving brackets in all mounting locations to maintain base clearance of at least 1" above floor or housekeeping pad.

2.9 TYPE 5 HANGERS (SPRING HANGER WITH NEOPRENE)

A. Mason Type 30N, vibration hangers with steel spring and neoprene element in series. Neoprene element shall be molded with rod isolation bushing that passes through hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit hanger rod to swing through 30° arc before contacting hole and short circuiting spring.

B. Mason Type DNHS may be used where load rating and specified deflection cannot be accommodated by Type 30N.

2.10 TYPE 6 HANGERS (PRECOMPRESSED SPRING HANGER WITH NEOPRENE)

A. Mason Type PC30N, vibration hangers similar to Type 5, but precompressed to rated deflection so as to keep piping or equipment at fixed elevation during installation. Design hangers with release mechanism to free spring after installation complete and hanger is subjected to its full load.

2.11 TYPE 7 HANGERS (SPRING HANGER WITH DEFLECTION INDICATOR)

A. Mason Type HES, steel spring in steel housing including deflection indicator scale. Hangers shall be preset at factory for required load. Select hangers so that actual loads do not exceed rated capacities (lbs).

B. Submittals shall include isolator rated deflection, required deflection and supporting calculation. Calculations shall be made by registered mechanical or civil engineer demonstrating structural adequacy of hanger and that hanger connections to building and pipe are adequate for live and dead loads encountered.

2.12 TYPE 8 HANGERS (SPRING HANGER WITH NEOPRENE)

A. Mason Type 30, W30, or PC30 steel spring located in neoprene cup manufactured with grommet to prevent short-circuiting of hanger rod. Neoprene cup to contain steel washer designed to properly distribute load on neoprene and prevent its extrusion. Spring diameters and hanger box lower hole size to be large enough to permit hanger rod to swing through 30 [illegible] short-circuiting spring. Provide hangers with rod attachments or eyebolts on spring end.

2.13 TYPE AG PIPE ANCHORS/GUIDES

A. Mason Type ADA all-directional acoustical pipe anchors and Type VSG guides for vertical piping consisting of telescopic arrangement of 2 sizes of steel tubing separated by minimum 1/2" thickness of heavy duty neoprene and neoprene isolation material. Vertical restraints shall prevent vertical travel in either direction. Allowable loads on isolation materials shall not exceed 500 psi and design shall be balanced for equal resistance in any direction.

B. Submittals shall include supporting calculations by registered mechanical or civil engineer indicating anchor/guide loads and isolator selection.

2.14 TYPE T THRUST RESTRAINTS

A. Mason Type WB, horizontal thrust restraint consisting of spring element in series with neoprene pad as described for Type 3 mounts with the same deflection as specified for mountings or hangers. Spring element shall be contained within steel frame and designed so it can be preset for thrust at factory and adjusted in field for maximum of 1/4" movement at start and stop. Furnish thrust restraints complete with rods and angle brackets for attachment to both equipment and ductwork or equipment and structure. Attach horizontal restraints at centerline of thrust and symmetrically on either side of unit.

2.15 FLEXIBLE PIPING CONNECTIONS

A. Flexible connection shall be suitable for pressure, temperature and fluid involved, but not less than 215 psig working pressure at 250°F for 14” and smaller and 150 psi working pressure at 250°F for 16” and larger.

B. Unless otherwise specified, minimum live length of metal flexible hose shall be length required to absorb 3/4" lateral movement, but not less than 12".

C. Piping connected to steam heating coils in floor mounted air handling units where coils are supported without vibration isolation shall have flexible piping connections and piping vibration hangers to prevent thermal stress in piping system from damaging the coils.

D. Water System:

1. Connections shall consist of Kevlar or Nylon tire cord fabric reinforced with EPDM cover and liner. Solid steel rings shall be used within raised face rubber flanged ends to prevent pullout. Flexible cable bead wire is not allowed. Furnish connections with control rod or cable assemblies as recommended by manufacturer.
2. 2" and Smaller: Threaded connections, single sphere design similar to Mason SAFEFLEX SFU.

3. 2-1/2" and Larger: Floating steel flange connections, two sphere design with ductile iron or plated carbon steel reinforcing rings, similar to Mason SAFEFLEX SFDEJ. Single sphere design similar to Mason SAFEFLEX SFEJ, may be used for 14" and larger.
4. Connection to Cooling Towers and Non-rotating Equipment Mounted on Vibration Isolators - Seamless corrugated bronze or stainless steel flexible hose with braided cover for 2" and smaller with threaded or flanged connections; seamless corrugated stainless steel flexible connector with braided cover for 2-1/2" and larger with flanged connections.

E. Steam and Condensate Including Pumped Condensate System:
1. Seamless corrugated stainless steel flexible hose with braided cover for 2" and smaller with threaded or flanged connections; seamless corrugated stainless steel flexible connector with braided cover for 2-1/2" and larger with flanged connections.

F. Fuel Oil System:
1. Seamless corrugated bronze flexible hose with braided cover.

G. Refrigerant System:
1. Seamless corrugated bronze flexible hose with bronze wire braided cover and standard copper tube ends for copper piping. Seamless corrugated stainless steel flexible connector with braided cover for steel piping.

H. Do not provide flexible piping connectors for compressed air piping.

I. Do not provide flexible piping connectors for gas piping.

2.16 PERFORMANCE

A. Select vibration isolation devices to achieve either minimum 95% isolation efficiency or minimum static deflection and mounting requirements listed below, whichever is greater. Minimum static deflections listed below are not nominal but certifiable minimums with actual installed load. Unless otherwise indicated, apply requirements listed for floor mount for roof-mounted equipment.

Type of Equipment	Ground Supported Slab		Floor Span							
			20 ft		30 ft		40 ft		50 ft	
	Type	Min Defl. (in)	Type	Min Defl. (in)	Type	Min Defl. (in)	Type	Min Defl. (in)	Type	Min Defl. (in)
Pumps:										
Close Coupled										
Thru 5 hp	Bolt to pad		3-I	0.75	3-I	0.75	3-I	0.75	3-I	1.5
7-1/2 hp and over	Bolt to pad		3-I	0.75	3-I	1.75	3-I	1.75	3-I	2.5
Flexible Coupled										
Thru 40 hp	Bolt to pad		3-I	0.75	3-I	1.75	3-I	1.75	3-I	2.5
50 - 125 hp	Bolt to pad		3-I	0.75	3-I	1.75	3-I	2.5	3-I	2.5

150 hp and over	Bolt to pad		3-I	1.75	3-I	1.75	3-I	2.5	3-I	3.5
Packaged Air Handling Units:										
Floor Mounted										
Thru 5 hp	2	0.35	3	0.75	3	0.75	3	0.75	3	0.75
7-1/2 hp and over	2	0.35	3	1.5	3	2.5	3	2.5	3	2.5
Thru 400 rpm										
7-1/2 to 40 hp	2	0.35	3	0.75	3	1.75	3	1.75	3-S	2.5
401 rpm and over										
50 hp and larger	2	0.35	3	0.75	3	1.75	3-S	2.5	3-S	3.5
401 rpm and over										
Air Compressors:										
Tank Mounted										
Thru 10 hp	3	0.75	3	0.75	3	1.75	3	2.5	3	3.5
15 hp and over	3-I	0.75	3-I	0.75	3-I	1.75	3-I	2.5	3-I	3.5
Base Mounted										
Thru 499 rpm	3-I	2.5	3-I	2.5	3-I	2.5	3-I	3.5	3-I	3.5
500 rpm and over	3-I	1.5	3-I	1.5	3-I	2.5	3-I	3.5	3-I	3.5
Vacuum Pumps:										
Task Mounted										
Thru 10 hp	3	0.75	3	0.75	3	1.75	3	2.5	3	3.5
Base Mounted										
All Sizes	3-I	0.75	3-I	0.75	3-I	1.5	3-I	1.5	3-I	2.5

Centrifugal Blowers:

Suspended	Use Type 5-T hangers with deflection from blower minimum deflection guide.
Floor Mounted	
Thru 40 hp with operating static pressure less than 4”	Use Type 3-S mount with deflection from blower minimum deflection guide. Provide Type T thrust restraint for fans operating at 2” or more static pressure.
50 hp and over and all fans operating at 4” or more static pressure	Use Type 3-I mount with deflection from blower minimum deflection guide.
Suspended	Type 5-T supports with deflection from blower minimum deflection guide.
Floor mounted	Use Type 2-T for 0.35” deflection, Type 3-T for 0.75” deflections and 3-S-T for deflections over 0.75” with deflection from blower minimum deflection guide.
Fan Coil Units and Heat Pump Units	Type 5 with minimum deflection of 0.5” for 600 cfm or less and 0.75” for over 600 cfm.

Piping Connected to Rotating or Recipro-Equipment:	Use flexible piping connections, and Type 6 hangers for distance of 100 pipe diameters or 50 ft away from equipment, whichever is greater. Hangers shall have minimum deflection of 0.75” for pipe sizes 3” and smaller, 1.5” for pipe sizes 4” through 6” and 2.5” for pipe sizes 8” and larger. For piping less than 2” in diameter, neoprene or felt pad inserted between pipe or pipe covering and clamp or hanger may be used in lieu of Type 6 hangers. Where piping is floor-supported, above requirements shall apply, but use Type 3 mounts instead of hangers. Flexible piping connection shall not be used for unit heaters and in-line pumps that are supported by connected pipes. Type 6 hangers with 1” minimum deflection shall be applied within one foot of both sides of in-line pump and for distance of 100 pipe diameters or 50 ft away from first hanger at in-line pump, whichever is greater.
Ductwork in Mechanical Equipment Rooms:	Use Type 8 hangers with 0.75” minimum deflection for ducts with cross sectional area greater than 2.0 sq ft, and where either air velocity is greater than 2000 fpm for distance 50 ft from fan.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and adjust vibration isolation devices as specified, as shown on drawings and according to manufacturer's recommendations.

B. In no case shall installation short circuit isolation devices. Install flexible piping connections on equipment side of shut-off valves.

3.2 INERTIA BASES (TYPE I BASES)

A. Provide required concrete for inertia bases. Refer to Section 20 0000 - General Mechanical Requirements for concrete work.

B. Raise inertia bases to final elevation with temporary blocking prior to making piping connections to pumps or ductwork connections to fans. After connections are complete, install vibration isolators in accordance with manufacturer’s installation instructions.

3.3 PACKAGED AIR HANDLING UNITS

A. Install Type T thrust restraints at fan sections when fan section is isolated from remainder of air handling unit.

3.4 FLEXIBLE PIPING CONNECTIONS

A. Provide flexible connections for piping connected to rotating or reciprocating equipment, equipment mounted on vibration isolators, and as indicated on plans and details.

B. For non-metallic flexible piping connections, 2-1/2" and larger, use flange type recommended by manufacturer. Flanges for mechanical grooved connections are not allowed.

End of Section

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SECTION 23 05 94

WATER SYSTEMS TEST ADJUST BALANCE

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 09 01 - Control Systems Integration

B. Section 23 09 93 - Control Sequences

C. Section 23 21 18 - Valves (balancing valves)

D. Section 23 21 20 - Piping Specialties (flow measure devices)

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. TAB Contractor shall be responsible for providing complete testing, adjusting and balancing (TAB) work for HVAC hydronic systems, such as chillers, pumps, convertors and other processes included in this project.

B. Work required shall consist of setting volume flow rates and adjusting speed controls, recording data, making tests, and preparing reports, as specified herein.

C. Scope of work includes TAB of new work specified herein and includes all equipment, distribution systems, and terminal units connected.

D. TAB work shall be performed by persons trained in TAB work and certified by Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB). Procedures shall be in accordance with the latest edition of AABC or NEBB Standards, ASHRAE - 2007 HVAC Applications Chapter 37, and as detailed herein.

E. Mechanical Contractors who are members of AABC or NEBB and who have qualified personnel available to perform work may submit Quality Assurance Submittal for approval. Mechanical Contractors who cannot meet these requirements shall subcontract with independent TAB Contractor who meets these requirements. TAB subcontractor shall prepare Quality Assurance Submittal for Contractor who will submit it for approval.

F. Upon direction of Architect/Engineer or TAB subcontractor, Mechanical Contractor shall provide at no additional cost to Laboratory, any additional work and/or devices necessary to properly balance system, including calibrated balancing valves, gauge tappings, flow sensors, and thermometer wells. Mechanical Contractor shall be responsible for trimming and balancing pump impellers as necessary to obtain design pump flow rates at the minimum pressure differential.

G. TAB work shall not proceed until all assigned personnel have been approved by Architect/Engineer via Quality Assurance Submittal. Coordinate each phase of TAB work with overall project schedule. Each phase of TAB work shall be done in timely manner as detailed herein. Fieldwork must be completed before occupancy. Certificate of Substantial Completion shall not be issued until after Final Report is accepted by Architect/Engineer.

1.4 SUBMITTALS

A. General:
   1. Make submittals in accordance with project submittal procedure. Submit minimum of 5 copies of submittals unless otherwise directed (3 for O&M Manuals, 1 for A/E, 1 for Contractor).
   2. Reports shall be assembled using 3-ring hard cover binder with project name and location on cover and side panel. Information sheets shall be 8-1/2" x 11" white bond paper. Use pre-printed forms of NEBB or AABC wherever possible. Provide sortable electronic version as well as hard copy. Provide numbered tabs for each system. Assemble report in the following order:
      a. Transmittal letter
      b. Cover sheet with project title, location, submittal date, and name and addresses of Laboratory, Mechanical Contractor, TAB subcontractor, Architect, and Engineer
      c. Index of numbered tabs listing major systems
      d. Data organized by system in the following order:
         1). Equipment data and measurement summary
         2). Equipment measurement data
         3). Branch main measurement data
         4). Terminal device measurement data arranged by room or zone

B. Quality Assurance Submittal:
   1. Within 30 days of signing contract, Contractor shall submit the following information:
      a. Firm resume
         1). AABC or NEBB active membership certificate
         2). Names of 3 recent relevant completed projects along with project address, Laboratory's contact person, supervising design professional
      b. Supervisor resume
      c. Balance technicians resumes
   2. Architect/Engineer and/or Laboratory reserves the right to contact previous project representatives and to reject persons whom Architect/Engineer and/or Laboratory feel are not qualified for this project due to lack of relevant experience or problems on previous projects.

C. Planning Report:
   1. Submit Planning Report as detailed in Part 3 of this Section to demonstrate to Architect/Engineer and Laboratory that proper procedures are being followed. Submit Planning Report after Quality Assurance submittal and 30 days before any fieldwork starts.

D. Initial Test Report:
   1. Prior to starting Final Balance Phase, submit Initial Test Report as detailed in Part 3 of this Section to indicate to Architect/Engineer and Contractor incomplete work or problem areas to be resolved before final balance is completed.

E. Final Report:
   1. Within 30 days after fieldwork is completed, submit Final Report as detailed in Part 3 of this Section to assure design objectives are met and to assist Laboratory in future maintenance.

1.5 REFERENCE STANDARDS

A. Refer to the latest publications of NEBB, AABC and ASHRAE publications for establishing required procedures.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

A. Provide required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements shall be in accordance with requirements of NEBB or AABC Standards and instrument manufacturer's specifications.

B. Instruments used for measurements shall be accurate, and calibration histories for each instrument shall be available for examination by Architect/Engineer upon request. Calibration and maintenance of all instruments to be in accordance with requirements of NEBB or AABC Standards.

PART 3 - EXECUTION

3.1 GENERAL

A. TAB work shall be done in separate phases as outlined herein. TAB schedule shall allow ample time to complete TAB work before occupancy. Follow procedures outlined herein and as described in Planning Phase narratives.

B. Unless otherwise specified, maximum acceptable offset tolerance shall be ± 10% of design flow rates indicated on drawings and schedules.

3.2 PLANNING PHASE

A. Procedure:

1. Obtain the latest Contract Documents including addenda, construction bulletins and change orders. Obtain shop drawings and performance curves from Mechanical Contractor for pumps, flow measuring devices, and terminal devices. Prepare Planning Report as detailed herein. Make adjustments in Planning Report and/or measuring instrument calibration.

B. Planning Report:

1. Planning Report shall contain the following minimum requirements.
2. Narratives: Furnish written narratives of procedures to be used. Include separate narratives for each pump and liquid fluid handling system. Identify flow-measuring devices to be used at each pump and terminal device. Include different narratives for constant and variable flow systems. For non-standard water systems, include narratives on how to measure and adjust for different viscosities. Narratives shall include references to published standards of NEBB or AABC. Narratives shall include measuring instruments to be used and ranges required for each procedure. Narratives shall include specified adjustment tolerances.
3. Prebalance Checklist: shall include, but not be limited to:
   a. Check for completeness of work
   b. System cleaning
   c. System fill and air venting
   d. Place system into operation
   e. Check expansion tanks and fill pressures
   f. Pump bearings, alignment, starters, vibration isolators, rotation
   g. Setting valves to proper position including shut-off and bypass valves
   h. Set up of controls and control devices

4. Measuring Instrument List: List that measuring instruments will be used for each procedure. Indicate ranges required for each procedure. Provide data on each measuring instrument to be used. This data shall include:
   a. Manufacturer name and model number
   b. Measurement range
   c. Pressure/temperature limits
   d. Date put into service
   e. Date of last calibration
   f. Certificate from calibration firm
5. Architect/Engineer reserves the right to request adjustments in any procedure and/or ask for recalibration of any measuring instrument that has not been recalibrated within past year.
6. Samples: Submit copies of TAB forms to be used.
7. Branch circuit and terminal measurements and adjustments: Indicate on pre-printed forms all measurements to be taken and adjustments to be made in field. Include branch circuit or terminal identification, system, space served, location, design flow rates (including zone and system summaries), and flow measuring device size, type, Cv, and manufacturer. Indicate the initial set points on forms.

3.3 SET-UP PHASE

A. Procedure:
   1. Perform prebalance checkout as per Planning Phase narrative.

B. Initial Test:
   1. Measure pump data and flow rates in "as found" condition after initial valve settings are made.

C. Initial Test Report:
   1. Submit report to Architect/Engineer and Mechanical Contractor indicating measurements made and including notes of items that are not complete or are not within design tolerance.

3.4 FINAL BALANCE PHASE

A. Procedure:
   1. Perform procedures as per Planning Phase narrative. Correct deficiencies and redo procedures as required prior to submitting Final Report.

B. Final Report:
   1. Submit report to Architect/Engineer and to Mechanical Contractor indicating all data, measurements and adjustments as per requirements herein and per Planning Phase narrative. Do not submit partial or incomplete reports.

C. Final Report Adjustments:
   1. Architect/Engineer reserves the right to check any measurement or adjustment made and to reject any portion of work not within specified tolerance. Contractor shall resubmit all or portions of Final Report as directed by Architect/Engineer.

End of Section

SECTION 23 05 95

AIR SYSTEMS TEST ADJUST BALANCE

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 09 01 - Control Systems Integration

B. Section 23 09 93 - Control Sequences

C. Section 23 33 14 - Ductwork Specialties

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. This Contractor shall be responsible for providing complete testing, adjusting and balancing (TAB) work for air systems, such as air handling units, return fans, exhaust fans, air terminal devices, diffusers, grilles and other air moving processes included in this project.

B. Work required shall consist of setting volume flow rates and adjusting speed controls, recording data, making tests, and preparing reports, as specified herein.

C. Scope of work includes TAB of new work specified herein and includes all equipment, distribution systems, and terminal units connected.

D. TAB work shall be performed by persons trained in TAB work and certified by Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB). Procedures shall be in accordance with the latest edition of AABC or NEBB Standards, ASHRAE - 2007 HVAC Application Chapter 37, and as detailed herein.

E. Mechanical Contractors who are members of AABC or NEBB and who have qualified personnel available to perform work may submit Quality Assurance Submittal for approval. Mechanical Contractors who cannot meet these requirements shall subcontract with independent TAB Contractor who meets these requirements. TAB subcontractor shall prepare Quality Assurance Submittal for Contractor to submit for approval.

F. TAB Contractor shall perform ductwork leakage tests. Refer to Section 23 3114 - Ductwork. Test equipment will be provided by Mechanical Contractor.

G. Upon direction of Architect/Engineer or TAB subcontractor, Mechanical Contractor shall provide at no additional cost to Laboratory, any additional work and/or devices necessary to properly balance system, including fan sheaves, motor sheaves and/or drive belts.

H. TAB work shall not proceed until assigned personnel have been approved by Architect/Engineer via Quality Assurance Submittal. Coordinate each phase of TAB work with overall project schedule. Each phase of TAB work shall be done in timely manner as detailed herein. Fieldwork must be completed before occupancy. Certificate of Substantial Completion shall not be issued until after Final Report is accepted by Architect/Engineer.

1.4 SUBMITTALS

A. General:
   1. Make submittals in accordance with project submittal procedure. Submit minimum of 5 copies of submittals unless more directed (3 for O&M Manuals, 1 for A/E, 1 for Contractor).
   2. Reports shall be assembled using 3-ring hard cover binder with Project Name and location on cover and side panel. All information sheets shall be 8-1/2" x 11" white bond paper. Use preprinted forms of NEBB or AABC wherever possible. Provide sortable electronic version as well as hard copy. Provide numbered tabs for each system. Assemble report in the following order:
      a. Transmittal letter
      b. Cover sheet with Project title, location, submittal date, and name and addresses of Laboratory, Mechanical Contractor, TAB subcontractor, Architect, and Engineer
      c. Index of numbered tabs listing major systems
      d. Data organized by system in the following order:
         1). Equipment data and measurement summary
         2). Equipment measurement data
         3). Branch main measurement data
         4). Terminal device measurement data arranged by room or zone

B. Quality Assurance Submittal:
   1. Within 30 days of signing contract, Contractor shall submit the following information:
      a. Firm resume
         1). AABC or NEBB active membership certificate
         2). Names of 3 recent relevant completed projects along with project address, Laboratory's contact person, supervising design professional
      b. Supervisor resume
      c. Balance technician(s) resume
   2. Architect/Engineer and/or Laboratory reserves the right to contact previous project representatives and to reject persons whom Architect/Engineer and/or Laboratory feel are not qualified for this project due to lack of relevant experience or problems on previous projects.

C. Planning Report:
   1. Submit Planning Report as detailed in Part 3 of this Section to demonstrate to Architect/Engineer and Laboratory that proper procedures are being followed. Planning Report shall be submitted after Quality Assurance submittal and 30 days before any fieldwork starts.

D. Initial Test Report:
   1. Prior to starting Final Balance Phase, submit Initial Test Report as detailed in Part 3 of this Section to indicate to Architect/Engineer and Contractor incomplete work or problem areas to be resolved before final balance is completed.

E. Final Report:
   1. Within 30 days after fieldwork is completed, submit Final Report as detailed in Part 3 of this Section to assure design objectives are met and to assist Laboratory in future maintenance.

F. LEED Submittal:
   1. Air Balance Report for LEED IEQ Prerequisite 1: Documentation of work performed for ASHRAE 62.1-2007, Section 7.2.2, “Air Balancing”.

1.5 REFERENCE STANDARDS

A. Refer to the latest publications of NEBB, AABC, ASHRAE, and Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) publications for establishing required procedures.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

A. Provide all required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements shall be in accordance with requirements of NEBB or AABC Standards and instrument manufacturer's specifications.

B. Instruments used for measurements shall be accurate, and calibration histories for each instrument to be available for examination by A/E upon request. Calibration and maintenance of instruments to be in accordance with requirements of NEBB or AABC Standards.

2.2 INSTRUMENT TEST HOLE PLUGS

A. Center-pull plugs similar to Alliance Plastics CP Series. Plug material shall be Grade 1 virgin polyethylene.

PART 3 - EXECUTION

3.1 GENERAL

A. TAB work shall be done in separate phases as outlined herein. TAB schedule shall allow ample time to complete TAB work before occupancy. Follow procedures outlined herein and as described in Planning Phase narratives.

B. Unless otherwise specified, maximum acceptable offset tolerance is plus or minus 10% of the design flow rates as indicated on drawings and/or as scheduled.

3.2 PLANNING PHASE

A. Procedure:

1. Obtain the latest Contract Documents including addenda, applicable construction bulletins and change orders. Obtain shop drawings and performance curves from Mechanical Contractor for fans, flow measuring devices, and all terminal devices. Prepare Planning Report as detailed herein. Make adjustments in Planning Report and/or measuring instrument calibration.

B. Planning Report:

1. Planning Report shall contain the following minimum requirements.

a. Samples: Provide copies of all forms to be used.

b. General narratives: Furnish written narratives of all procedures used. Include separate narratives for each fan and air handling system. Identify flow-measuring devices to be used at each fan, air terminal device, and air outlet. Narrative shall include statement that every air outlet shall be measured and adjusted. Provide different narratives for constant and variable flow systems. Narratives shall include references to published standards of NEBB or AABC. Narratives shall include measuring instruments to be used and ranges required for each procedure. Narratives shall include specified adjustment tolerances.

c. Air system narratives: Provide narratives for each air system which shall include procedures for measuring static pressures at each component of air handling system to generate a static pressure profile. Measurements shall be made to measure performance of system in all operating modes

including economizer mode using 100% outside air where applicable. Differentiate between constant and variable flow systems.

d. Non-standard air system narratives: Include narratives on how to measure and adjust for different air densities for systems with static pressures greater than 8" WG or temperatures greater than 140°F.

e. Air terminal narratives: Narratives shall describe procedures for measuring flows and adjusting controls to meet specified minimum and maximum flow rates based on actual field installed conditions.

f. Branch duct and air outlet measurements: Indicate on preprinted forms all measurements to be taken in field. Include branch duct or air outlet identification, system, space served, location, and design flow rates (include zone and system summaries). Indicate duct or air outlet neck size, make, model number, Ak factor, and design velocities.

g. Pressure relationship test narrative: Narratives shall describe how to obtain and measure pressure relationships between spaces as per schedule or as listed below.

1). Laboratories

h. Fume Hood Certification: Narrative shall include procedures as described in Scientific Equipment and Furniture Association (SEFA) Standard SEFA 1-2006. Each hood shall be labeled with:

1). Test date

2). Name of tester

3). Sash position at 80 fpm, 100 fpm and 125 fpm

4). Hood Classification

i. Refer to fume hood specification for sash type of each hood, design exhaust rate and sash design opening size. Design airflows are based on design operating sash opening and 100 fpm face velocity at the sash opening. Hoods handling isotopes shall have minimum face velocity of 125 fpm.

2. Prebalance Checklist - to include, but not limited to:

a. Check for completeness of work

b. System cleaning if required

c. Check fire, smoke and balancing damper positions

d. Place system into normal operation without economizers.

e. Install test openings where required.

f. Indicate type of test holes to be used and installation procedure.

g. Note condition of filters.

h. Provide temporary blankoffs to simulate design pressure drops of filters.

i. Chisel holes and duct tape are not allowed.

j. Wet cooling coils

k. Fan wheels, blades, bearings, alignment, starters, vibration isolators, and rotation

l. Drive belt tension and alignment

m. Setting of automatic dampers to proper position including shutoff and bypass dampers

n. For hoods and ovens indicate temperature and humidity. Correct for density changes.

o. Set up of controls and control devices

3. Measuring Instrument List - list what measuring instruments will be used for each procedure. Indicate ranges required for each procedure. Provide data on each measuring instrument to be used. This data shall include:

a. Manufacturer name and model number

b. Measurement range

c. Pressure/temperature limits
d. Date put into service
e. Date of last calibration
f. Include certificate from calibration firm

4. Architect/Engineer reserves the right to request adjustments in any procedure and/or ask for recalibration of any measuring instrument, which has not been recalibrated within past year.

3.3 SET-UP PHASE

A. Procedure:
1. Perform prebalance checkout as per Planning Phase narrative.

B. Initial Test:
1. Measure fan data and flows in "as found" condition after initial damper settings are made.

C. Initial Test Report:
1. Submit report to Architect/Engineer and Mechanical Contractor indicating all measurements made and make notes of all items, which are not complete or are not within design tolerance.

3.4 FINAL BALANCE PHASE

A. Procedure:
1. Perform all procedures as per Planning Phase narrative. Correct all deficiencies and redo procedures as required before submitting Final Report.

B. Final Report:
1. Submit report to Architect/Engineer and Mechanical Contractor indicating all data and measurements as per requirements herein and per Planning Phase narrative. Do not submit partial or incomplete reports.

C. Final Report Adjustments:
1. Architect/Engineer reserves the right to check any measurement made and to reject any portion of work not within required tolerance of design flow. TAB Contractor shall resubmit all or portions of Final Report as directed by Architect/Engineer.

End of Section

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SECTION 23 09 01

CONTROL SYSTEMS INTEGRATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 05 13 - Motors

B. Section 20 05 14 - Variable Frequency Drive (VFD)

C. Section 23 05 50 - Vibration Isolation

D. Section 23 09 02 - Control Valves And Dampers

E. Section 23 09 03 - Control Instrumentation

F. Section 23 09 23 - Direct Digital Controllers and Networks

G. Section 23 09 24 - Graphical User Interface Integration

H. Section 23 09 93 - Control Sequences

I. Section 23 21 18 - Valves

J. Section 23 36 00 - Air Terminal Devices

K. Section 26 05 33 - Raceway and Fittings

L. Section 26 05 19 - Conductors and Cables

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 DEFINITIONS

A. The following abbreviations, acronyms, and definitions may be used in addition to those found elsewhere in Contract Documents.

1. Actuator: Control device to provide motion of valve or damper in response to control signal.
2. AI: Analog Input
3. AO: Analog Output
4. Analog: Continuously variable state over stated range of values
5. Auto-Tune: Software routine used to adjust tuning parameters based on historical data.
6. BAS: Building Automation System
7. BMS Building Management System
8. DDC: Direct Digital Control

9. DDCP:	Direct Digital Control Panel
10. Discrete:	Binary or digital state
11. DI:	Discrete Input (Sometimes referred to as Binary Input BI)
12. DO:	Discrete Output (Sometimes referred to as Binary Output BO)
13. EMCS:	Energy Management and Control System (Typically interchangeable with BAS or BMS)
14. E/P:	Voltage to pneumatic transducer (Often solenoid valve is referred to as an E/P transducer)
15. FA	Field Adjustable
16. FC:	Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
17. FMS:	Facility Management System linking two or more BAS
18. FO:	Fail Open position of control device or actuator. Device moves to open position on loss of control signal or energy source.
19. I/P:	Current to pneumatic transducer
20. Instrument:	Device used for sensing input parameters or used for actuation.
21. Modulating:	Movement of control device through an entire range of values proportional to an infinitely variable input value.
22. Motorized:	Control device with actuator
23. NC:	Normally Closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
24. NO:	Normally Open position of switch after control signal is removed or normally open position of manually operated valves or dampers.
25. Node:	DDCP, operator workstation, or other control device connected to communications network.
26. Operator:	Same as actuator for motorized devices. Also refers to an individual who physically "operates" facility.
27. PC:	Personal Computer
28. Peer-to-Peer:	Mode of communication between controllers in which each device connected to network has equal status and each share its database values with other devices connected to network.
29. P:	Proportional control, control mode with continuous linear relationship between observed input signal and final controlled output element.
30. PI:	Proportional - Integral control, control mode with continuous proportional output plus additional change in output based on both amount and duration of change in controlled variable (reset control).
31. PID:	Proportional - Integral - Derivative control, control mode with continuous correction of final controlled output element versus input signal based on proportional error, its time history (reset), and rate at which its changing (derivative).
32. Point:	Analog or discrete instrument with addressable database value.
33. Self-Tune:	Same as Auto-Tune
34. Solenoid:	Electric two-position actuator. (See E/P.)
35. TCC:	Temperature Control Contractor (Same as Control Contractor)
36. TCP:	Temperature Control Panel

1.4 ACCEPTABLE CONTROL CONTRACTORS

A. Control Contractor shall have full service office within 100 miles of project site. Full service office is defined as being home office of applications engineers, supervisors, and field technicians, having complete parts inventory, and having required test and diagnostic equipment. Control Contractors shall be factory authorized agent or dealer of controllers and control hardware as manufactured by:

1. Johnson Controls, Inc.

1.5 SYSTEMS DESCRIPTION

A. Control system shall be Direct Digital Control (DDC).

B. Damper and valve actuators shall be electronic type, unless otherwise noted.

C. Control system shall be 100% DDC unless otherwise indicated.

D. The existing campus Building Automation System is a Johnson Controls (JCI) "Metasys Extended Architecture" system.

E. The new BAS shall seamlessly integrate with existing Laboratory site JCI web server operator interface. This web server shall be able to access and read all input, output and calculated points and issue commands to all output points in the new BAS by means of a standard web browser. This Contractor shall provide all necessary hardware and software components to accomplish this interface.

F. BAS network architecture shall be based on an open implementation of BACnet using ASHRAE 135-2004 being the earliest accepted form of said protocol. This communications protocol shall be used for communication between DDC hardware devices and BAS Web Server, to allow multi-vendor interoperability. System shall support operator workstations as specified and shall be capable of additional workstations, limited only by systems maximum node capacity.

G. Provide BAS architecture consisting of communication network, modular designed DDCP with all points addressable and modifiable from operator workstations or from master DDCP using laptop computer. BAS shall be fully expandable with addition of hardware and/or software. Expansion shall not require removal of existing DDCP, sensors, actuators, or communication networks.

H. Operator workstations connected to the building Ethernet network shall be able to access BAS information as determined by the Graphical User Interface (GUI) software through standard web browsing software (Internet Explorer, Mozilla Firefox, Opera, or Google Chrome). The GUI software shall allow transparent access to each building component/system for control and/or monitoring.

I. System intelligence shall be such that engineering workstation(s) can be used for programming controls, performing analysis on filed data, generating maintenance and operation reports and providing permanent storage for programs and data.

J. Safety devices shall function in both auto and hand modes on starter.

1.6 SCOPE OF WORK

A. Provide all labor and materials for complete fully functioning control systems in accordance with Contract Documents including this Section plus:

1. Section 23 0902 - Control Valves and Dampers
2. Section 23 0903 - Control Instrumentation
3. Section 23 0905 - DDC Point Schedule
4. Section 23 0923 - Direct Digital Controllers and Networks

5. Section 23 0924 - Graphical User Interface Integration
6. Section 23 0993 - Control Sequences

B. Engineering services shall be performed by Factory Trained Engineers. System shall be installed either by trained mechanics directly employed by Control Contractor or by subcontractors who are under direct supervision of Control Contractor's representative. Engineer reserves right to exclude Project Managers, Engineers, Field Supervisors, or Technicians whose past experience is not sufficient to meet needs of Project.

C. Control Contractor’s Project Managers, Engineers and Digital System Programmers shall have previously performed in capacity that qualifies them to successfully engineer system of scope and magnitude similar to this Project.

D. Submit qualification of Project Managers, Engineers, Programmers, Field Supervisors, and Technicians to be assigned to this Project within 30 days after contract award. Use Qualification Form attached at end of this Section.

E. Labor shall include, but not be limited to:
1. Engineering services to size unscheduled valves and dampers based on design criteria specified in Section 23 0902 - Control Valves and Dampers, and confirm sizing of scheduled valves and dampers.
2. Engineering services to produce requested submittals and working construction drawings and record drawings as specified here within.
3. Engineering services for required software programming.
4. Engineering services for graphics programming specified.
5. Project management services as single point contact to coordinate construction related activities.
6. Field mechanics for installation of pneumatic tubing and related control devices.
7. Field mechanics for installation of control wiring and related control devices.
8. Field technicians to startup, calibrate, adjust, and tune control loops.
9. Field technicians to perform system checkout and testing, and to complete required reports.
10. Field supervisor during controls installation and startup.
11. Field technicians to assist Testing and Balancing (TAB) Contractor in adjusting controls and determining setpoints related to TAB work.
12. Field representatives and/or classroom instructors to provide Owner training as specified.

F. Control Contractor shall be responsible for complete installation of control devices (except as noted), wiring, and pneumatic terminations at controller locations to accomplish control sequences specified in project manual or on drawings. Control Contractor is required to provide power for air terminal controllers and other field mounted devices that require 24 VAC, 60 Hertz and shall be powered from 120 to 24 VAC transformer panels provided by Control Contractor. Control Contractor shall also be responsible for additional instrumentation described in point schedules found in Contract Documents, which may not be directly related to specified control sequences.

G. Mechanical Contractor shall provide wells, taps, and other mechanical interfaces required for control equipment mounting into piping systems. Mechanical Contractor shall install in-line mounted devices, such as valves, dampers, flow meters, static pressure probes, etc., furnished by Control Contractor. Control Contractor shall be responsible for installation of other control devices, such as actuators, linkages, sensors, air terminal controllers, flow transducers, remote mounted control devices, control panels, control transformers, etc.

H. Electrical work required as integral part of control work is responsibility of Control Contractor. Control Contractor is responsible for providing final power connections, including conduit, wire, and/or disconnect switches, to control devices from appropriate electrical distribution panels.
1. Electrical Contractor will provide circuit breakers required to provide electrical power to controllers.

2. 120 to 24 VAC transformer panels shall be provided by Control Contractor and mounted adjacent to controller panels or in Mechanical or Intermediate Distribution Frame (IDF) rooms and powered from dedicated electrical circuit.
3. Should any change in number of controllers or addition of other electrical equipment after Contracts are awarded, Control Contractor shall immediately notify Electrical Contractor of change. Additional costs due to these changes shall be responsibility of Control Contractor.
4. Coordinate with Electrical Contractor for additional power requirements.

I. Materials shall be as specified unless approved through procedures for product substitution specified in Division 01. Control Contractor shall provide components not specifically indicated or specified, but necessary to make system function within the intent of specification.

J. Electrical products shall be listed and labeled by UL and comply with NEMA Standards.

K. Provide weather protection cover or weatherproof control devices where required for control devices located outdoors.

L. BAS contractor is responsible for integration of the following independent systems into the BAS:
1. Electrical Metering.
   a. Electrical Metering provider will provide Modbus TCP connection(s) for interfacing to the BAS. Control contractor responsible for a BAS solution to communicate data directly or through a gateway to all suppliers listed in Division 26 for Electrical Metering. Control contractor and Electrical Metering provider responsible for coordination of gateway requirements if needed, translation of network protocols, testing of communications between systems, and joint commissioning of systems. Control contractor to refer to P&ID's, Section 26 2413 Switchboards and Section 26 2713 Electrical Metering for programming and monitoring requirements.
2. Variable Frequency Drives (VFD):
   a. VFD provider will provide a termination point for a single point communication connection to the BAS utilizing BACnet MS/TP protocol. BAS Contractor shall provide cabling and conduit to make an interface connection from the BAS to the VFD. BAS Contractor and VFD provider responsible for translation of network protocols, testing of communications between systems, and joint commissioning of systems. BAS Contractor to refer to P&ID's, and Section 20 05 14 Variable Frequency Drive (VFD) System and for programming and monitoring requirements.
3. Heat Recovery Units (TEW & PDW):
   a. Heat Recovery Unit provider will provide a termination point for a single point communication connection to the BAS utilizing BACnet MS/TP protocol. BAS Contractor shall provide cabling and conduit to make an interface connection from the BAS to the Heat Recovery Unit controller. BAS Contractor and Heat Recovery Unit provider responsible for translation of network protocols, testing of communications between systems, and joint commissioning of systems. BAS Contractor to refer to P&ID's, and Section 23 7214 Heat Recovery Equipment for programming and monitoring requirements.

1.7 SUBMITTALS

A. Extended Service Agreement:
1. Control manufacturer shall, upon completion of warranty period, make available to Owner annual service agreement covering all labor and material required to effectively maintain control system after warranty period. Owner reserves the right to accept or reject any such offers and to cancel on-going agreements with 30-day written notice.

B. Shop Drawings:
1. Submit manufacturer's printed product data sheets for control devices and materials listed in bill of material in Control Contractor's control drawings. Datasheets shall be submitted electronically in pdf

format with bookmarks provided for each individual device and table of contents listing each device manufacturer and full model number and active link to respective datasheet. Organize sheets in order of manufacturer & model number, alphabetically, then numerically. When a manufacturer's data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Data sheets shall include sufficient technical data to describe device parameters required as specified.

2. Submit data concerning type of signal wiring and installation methods including raceway types and grounding methods.
3. Submit engineering calculations for sizing air compressor assembly if pneumatic control system is specified.
4. Submit control drawings including, but not limited to, the following:
   a. Front sheet index for projects with more than 10 control drawing sheets.
   b. Overall system/network architecture drawings: Provide block diagram showing relationship of each controller, control panel, or other network devices relative to each other. Label room location of each device. Number and indicate model number of each device. Indicate network types.
   c. Control Drawings: Including graphic representation of systems with major in-line components to properly locate all control devices. Identify controlled devices with their software designation on drawings, including unique valve and damper tag numbers.
   d. Detailed wiring and piping diagrams showing point-to-point hookup details of transducers, relays, outputs, inputs and subsystem components. Label pneumatic lines and control wires with field ID numbers/colors.
   e. Bill of material identifying actual product model number used for each control device for each schematic control drawing.
   f. Drawings showing proposed locations of sensors and flow meters in ductwork and piping systems.
   g. Sequence of operation: Provide written narrative describing each control sequence indicating method of control. Identify sensors, controllers, and actuators used with references to tag number of controlled device. Include set points of each control loop.
   h. BACnet Compliance Documentation: The Protocol Implementation Conformance Statement for each component.

C. Thermostat/Room Sensor Schedules:
   1. Submit thermostat/room sensor schedule with shop drawings. Thermostat/room sensor schedule shall have detailed listing of which type is used for each room including data concerning service and model numbers, sizes, cover types, and engineering data sheets for each control device.

D. Completion Checklist:
   1. Submit with shop drawings, detailed completion checklist including written procedures for adjusting and calibrating each type of instrument and sensor. Engineer reserves the right to request modifications to any procedure, which is incomplete or not adequate to prove system performance.
   2. Checklist shall include references to the following additional requirements:
      a. Instruments and sensors shall be calibrated by comparison to known device, which is traceable to National Institute of Standards and Testing.
      b. Each point shall be checked for calibration, connection to correct control loop, and proper setting of limit and alarm values.
      c. Transducers and other output devices shall be properly zeroed and calibrated at both minimum and maximum output. Document settings for discrete instruments and set points for analog instruments shall include minimum and maximum positions for safe operating conditions where applicable (max. pump speed or max. frequency of fan drive, etc.).
      d. Control loops shall be tuned to maintain controlled process variable at set point through seasonal conditions without operator intervention. Provide multiple sets of tuning parameters if necessary.

Controller shall automatically use tuning parameters appropriate to existing ambient conditions. Maintain record on completion checklist, of control loops that require tuning at alternate times of year. Instruct technicians to supply default parameters that can approximate stable control until actual load conditions allow proper tuning of control loops.

e. Performance tests of analog control loops shall be performed by changing set points and verifying that sequences can come into stable control within reasonable time period appropriate for each sequence. Simulate load changes for pressure and flow control loops.

f. Performance tests of discrete control loops shall be performed by adjusting set point and verifying sequence action.

g. Alarms, including network failures, shall be tested for each controller and device connected to network. Ensure that alarms are properly acknowledged at operator's workstation.

E. Warranty

1. Provide at minimum 1 yr warranty on all materials and labor.
2. Warranty requirements shall include furnishing and installing software upgrades issued by the manufacturer during the minimum 1 yr warranty period.

F. Control Contractor and Mechanical Contractor shall walk proposed static pressure sensor and flow meter locations and mark up drawings for review and approval by Owner and Engineer prior to installation.

1.8 COORDINATION WITH TAB CONTRACTOR

A. Control Contractor shall allow sufficient time to provide assistance and instruction to TAB Contractor in proper use and setting of control components such as, Operator Workstation computers, static pressure controllers, "K" Factors for VAV boxes, or any other devices that may need set points changes so that TAB work can be performed.

B. Provide required hardware and software related to control system to TAB Contractor to allow testing of systems and continued operation.

1.9 OPERATION AND MAINTENANCE MANUALS

A. Refer to Division 01 - General Requirements.

B. Operation and Maintenance manuals shall provide descriptions of maintenance on all system components, including sensors and controlled devices. Descriptions shall include:

1. Product manuals for the key software tasks.
   a. Operating the system.
   b. Administering the system.
   c. Engineering the Operator workstation.
   d. Application programming.
   e. Engineering the network.
   f. Setting up the web server.
   g. Report creation.
   h. Graphics creation.
   i. Data backup & Archiving.
2. List of recommended maintenance tasks associated with the system, operator workstations, data servers, web servers, and web clients.
   a. Define the task.
   b. Recommend a frequency for the task.
   c. Reference the product manual that includes instructions on executing the task.

3. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
4. Licenses, guarantees, and warranty documents for equipment and systems.
5. System architecture diagram for components within the building annotated with specific location information.
6. As-built drawing for each control panel.
7. As-built wiring design diagram for each control panel.
8. As-built wiring design diagram for all components.
9. Installation design details for each I/O device, including all IP addresses.
10. As-built system flow diagram for each system.
11. Sequence of control for each system.
12. Binding map for the building.
13. Product data sheet for each component.
14. Installation data sheet for each component
15. Control Contractor's completion checklist.

1.10 RECORD DRAWINGS

A. Refer to Division 01 - General Requirements.

B. Submit revised shop drawings indicating changes made during Project.

C. Update control diagrams to include tuning parameters and set points applicable to systems depicted as of date of system completion. This information shall be incorporated with sequence of operation for each system.

D. Include floor plans showing location of control panels and routing of BAS network cabling.

E. Software
1. Submit a copy of all software installed on the servers and workstations.
2. Submit all licensing information for all software installed on the servers and workstations.
3. Submit a copy of all software used to execute the project even if the software was not installed on the servers and workstations.
4. Submit all licensing information for all of the software used to execute the project.
5. All software revisions shall be as installed at the time of the system acceptance.

F. Firmware Files
1. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project.
2. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
3. Submit a copy of all application files that were created during the execution of the project.
4. Submit a copy of all graphic page files created during the execution of the project.
5. Submit a copy of all secondary graphic files such as bitmaps, jpegs, etc. that were used in the creation of the graphic pages.

1.11 OWNERSHIP OF PROPRIETARY MATERIAL

A. The Owner shall retain all rights to software for this project.

B. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to the Owner as defined by the manufacturer's license agreement, but shall protect the manufacturer's rights to disclosure of Trade Secrets contained within such software.

C. The licensing agreement shall not preclude the use of the software by individuals under contract to the Owner for commissioning, servicing, or altering the system in the future. Use of the software by individuals under contract to the Owner shall be restricted to use on the Owner's computers and only for the purpose of commissioning, servicing, or altering the installed system.

D. All project developed software, files and documentation shall become the property of the Owner. These include but are not limited to:
   1. Server and Workstation software
   2. Application Programming Tools
   3. Configuration Tools
   4. Addressing Tools
   5. Application Files
   6. Configuration Files
   7. Graphic Files
   8. Report Files
   9. Graphic Symbol Libraries
   10. All Documentation.

PART 2 - PRODUCTS

2.1 CONTROL WIRING

A. Control wiring shall be in accordance with National Electrical Code and Local Electrical Codes. Final connection points at devices and panels shall be made either at terminal blocks integral to device or at separate terminal blocks mounted inside of control panel enclosures. Use of wire nuts and crimped connections are not allowed for terminating control wiring unless approved by Engineer.

B. Refer to Division 26 for specification requirements for conduits and conductors, except as noted.

C. Signal and Power Conductors (24 V and Under):
   1. Wires smaller than #18 AWG shall not be used, except for manufacturer supplied instrument specific wire, or where otherwise specified. Use 2-wire stranded twisted/shielded pair 24 VDC for analog and discrete input and 24 VAC/VDC output devices. For 3-lead RTD signal wiring, use #18 AWG stranded, tinned copper twisted/shielded 3-conductor. Provide 250 ohm, 5 watt, 0.1% tolerance dropping resistors in 4 - 20 mA circuits as required to generate 1 to 5 volt signals in 24 VDC powered instrument loops. Provide isolated instrument grounding system as per manufacturer's recommendations.
   2. Conductors not concealed in raceway shall have UL Listed plenum rated Teflon insulation.
   3. Communication Cable: Use control system manufacturer's standard communications cable or #22 to #24 AWG twisted, shielded pairs, coaxial cable, or fiber optics for communications between remote controllers/devices.
   4. 24 VAC Power Conductors shall be #18 AWG 2 wire twisted pair or larger. Provide Metal Oxide Varistors (MOVs) on 24 VAC/VDC discrete outputs connected to inductive loads to reduce noise levels (i.e., solenoid valves, motor contactors, relays, damper/valve electric actuators, etc.).

5. Stranded twisted/shielded control conductors are required with shields to be terminated within variable frequency Drive enclosures to reduce effects of noise from VFD. Follow VFD manufacturer's installation instructions for wiring control conductors to VFD.

D. Transient Voltage Surge Suppression Devices:

1. Devices shall be designed for 120-volt power conditioning devices for electronic equipment. Devices shall be designed, manufactured, tested, and installed in compliance with ANSI/IEEE C62.41 and C62.45, Federal Information Processing Standards Publication 94 (FIPS PUB 94), NEMA, NFPA 70, 75, and 78, and UL 1449 and 1283. Devices shall be labeled for UL 1449.
2. Clamping voltage for 120 V power systems shall be 400 V.
3. Provide visual indicator of when surge device has been used.

E. Uninterruptible Power Supply

1. Manufacturers: MGE UPS Systems, Eaton Powerware, Liebert PowerSure or approved equal
2. Provide UPS for backup power for Operator Workstations, Building Level Controllers, Floor Level Controllers and field panels required for control of emergency/standby powered equipment, UPS shall maintain control upon loss of normal power and until emergency/standby power supply is brought on line.
3. Select UPS for minimum of 5 minutes backup time for load connected. This will allow emergency/standby power sources to come on line and provide backup power to emergency/standby powered equipment.
4. Upon sensing loss of normal power, transfer time shall be 8 milliseconds maximum.
5. Operating Parameters:
   a. Operating Temperature: 32°F to 104°F
   b. Relative Humidity: 0 to 95% rh, non-condensing
   c. Recharge Time: 8 hours, typical
6. UPS shall have self-diagnostic capability with DO to BAS to allow remote monitoring/alarming of UPS trouble or alarm conditions.

2.2 AIR PIPING

A. Copper Tubing:

1. Type L, hard or soft seamless, ASTM B88, with wrought copper soldered fittings, ANSI B16.22, except at connections to apparatus, where brass compression-type fittings shall be used. Solder joints shall be made with ASTM B32, 95-5 tin-antimony solder-joint, Bridgit or Silvabrite.

B. Plastic Tubing:

1. Fire resistant virgin polyethylene, meeting stress-crack test ASTM D1693-60T. Individual tube polyethylene or multi-tube instrument tubing bundle shall be classified as flame retardant under UL 94 and polyethylene material shall be rated as self-extinguishing when tested in accordance with ASTM D 635.
2. Isolation valves for air piping shall be threaded or soldered, 2-piece, bronze ball valves as per Section 23 2118 - Valves, suitable for intended service and pressure.

2.3 LOCAL CONTROL PANELS

A. Unless otherwise indicated, local control panels shall be manufacturer’s standard panels.

B. Construction for exterior panels shall comply with NEMA 4X.

C. Control panels located in mechanical or electrical rooms shall comply with NEMA 4 requirements.

D. Provide panels of adequate size to accommodate instruments for future expansion of approximately 25% beyond space required for this scope of work.

PART 3 - EXECUTION

3.1 GENERAL

A. Install control equipment in a neat and workmanlike manner.

B. Coordinate timely delivery of materials and supervise activities of other trade contractors to install devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, valves, dampers, and other such items furnished by Control Contractor, which are to be installed by Mechanical Contractor.

C. Install control devices in accessible location.

D. No devices containing mercury shall be allowed under this Specification.

E. Coordinate mounting height and location of control devices so that NEC workspace clearances are maintained.

3.2 CONTROL WIRING

A. Provide electrical wiring required for complete functional control systems, including power circuit to control panels, both line and low voltage, in accordance with applicable local codes, and latest version of National Electrical Code and NFPA. Refer to Paragraph 1.6.H. for definition of scope of Work.

B. Control panels serving equipment fed by emergency/standby power shall also be served by emergency/standby power. Equipment fed by emergency/standby power is so indicated on mechanical equipment schedules and electrical motor schedules. Control panels shall be powered by local UPS (Uninterruptible Power Supply) to ensure continued control of equipment powered by site standby power sources when primary power source is lost. Devices such as Operator Workstations, Floor Level and Building Level Controllers, Application Specific Controllers and fume hood controls shall be provided with UPS power.

C. Power wiring to control compressors and dryers will be provided by Electrical Contractor. Furnish field-mounted starters to Electrical Contractor for installation and supervise installation.

D. Install control wiring in raceway system per Division 26 - Electrical, except as noted.

E. Tag each wire termination at control panels, junction boxes, and remote control devices with unique wire ID number.

F. Low voltage wiring concealed above accessible ceilings does not require raceway. Cables not in raceway shall be routed along building structure lines using Bridal Rings, J-hooks or other mounting methods as approved by Engineer. Use of wire-ties for attaching cabling to duct brackets, piping or structure is not acceptable. Diagonal routing is not allowed. Label each cable not in raceway with unique wire ID number every 50 ft.

G. Terminate low voltage DC instrument signal cable with black terminated on positive terminal and white terminated on negative unless otherwise noted.

H. Run direct current instrument conductors separately from alternating current conductors. Where allowed by NEC wiring classification, AC-DC route crossings shall be at 90 degrees. Install special sensor to transmitter cables in accordance with manufacturer's installation drawings or in compliance with manufacturer's

instructions. Extra precautions shall be taken when pulling and shortening these "vendor furnished" cables. Any extra length on these cables shall be neatly coiled into minimum 3" diameter coils and installed into junction box.

I. Route intrinsic safe wiring separately from other conductors. These conductors shall not be run with, nor cross, conductors of other NEC classifications and shall require intrinsic barrier if run in the same path with wiring of other classifications.

J. Follow Control Contractor’s Company standard cabling color codes.

K. Electric Signal Cables:
   1. Analog electric signal cables from electronic transmitters to controllers/receivers and from controllers to other analog devices shall be continuously shielded to reduce effects of EMI on control signals residing on those cables. Electric signal cables to discrete devices typically do not require shielding, but for better noise immunity use twisted/shielded pairs.
   2. Shields shall be grounded at power source end only and floated at other end. Pay particular attention to floating shields through termination points, maintaining only one single grounding point, and insulating from ground at other points.
   3. Provide 250 ohm, 5 watt, 0.1% tolerance, dropping resistors as required to generate 1 - 5 VDC signals from 4 - 20 mA control loop powered by 24 VDC power supply.

L. BAS Network Communication Cable:
   1. Install special cable connectors in accordance with BAS manufacturer's recommendations.
   2. Typically #22 AWG, but no smaller than #24 AWG, twisted pairs, twisted shielded pairs, coaxial cable, fiber optics or manufacturer's standard cabling for communications between remote control devices and BAS controllers.
   3. BAS Network communication cable shall not be spliced.
   4. Provide isolated instrument grounding system as necessary per manufacturer's recommendations.

3.3 AIR PIPING

A. Conceal all piping, except for piping in mechanical rooms and other areas where mechanical system piping is exposed.

B. Install exposed piping and conduit parallel to or at right angles to building structure and support adequately at uniform intervals.
   1. Use only tool-made bends.
   2. Provide tubing clamps with insulated standoffs where metallic tubing may come into contact with other dissimilar metals to prevent galvanic corrosion from occurring. Use of wire ties or hose clamps to fasten tubing to structure or other piping is not allowed.
   3. Use of tubing channel designed for mounting metallic or polyethylene tubing shall be allowed.

C. Polyethylene tubing not exceeding 18" exposed may be used for connection to instrument or actuator.

D. Install polyethylene tubing with no concealed splices and number code all tubing.

E. Piping type shall be as follows:
   1. Inside Panels:
      a. Use polyethylene tubing.
   2. Exposed:
      a. Use hard copper tubing unless otherwise noted.

b. Polyethylene tubing may be used if run in fully enclosed rigid metal raceway or metal conduit where environment is within temperature limits of polyethylene tubing. Use PVC coated copper tubing or stainless steel tubing for wet environments.

3.4 LOCAL CONTROL PANELS

A. Provide local control panel for each system where more than one control device requires field mounting, (air handling units, exhaust fans, miscellaneous control systems including pump controls, heat exchanger controls, etc.). Single devices may be mounted on piping, wall or ductwork. Install local control panel where indicated on drawings or suitable location adjacent to system served.

B. Mount panels on wall with suitable brackets or on self-supporting stand. Mount top of panels no higher than 6 ft above floor. Install panels so front cover door can swing fully open without interference.

C. Label local control panels with respective unique ID numbers in accordance with Section 20 0553 - Mechanical Identification.

D. Panel Layout:
1. Separate 24 VDC and 120 VAC, wire, cable, and devices by 6" minimum space.
2. Enclose wire and cable in wireways or bundle w/ wire ties and secure to back-panel. This does not apply to wire exiting wireways to terminal strips or panel mounted devices.
3. Space controllers according to manufacturer's requirements with 3" minimum between controllers and other devices on panel and 6" between controller front and door mounted devices. Ensure adequate space is allowed for device heat dissipation.
4. Do not place controller or control devices on enclosure sides.
5. Do not use any control panel as wire or cable pass-through to adjacent panel.

3.5 ADJUSTMENT AND COMPLETION CHECKLIST

A. After completion of installation, follow checklist procedure defined in checklist submittal to adjust and calibrate thermostats, control valves, control actuators, controllers, sensors, and other equipment provided in this Contract. Include signed and dated, completed checklist in Operation and Maintenance Manuals.

B. Upon completion of Work but before final acceptance of systems, Engineer or Owner's representative will verify performance of control loops. Control Contractor shall immediately remedy any deficiencies found. Corrective measures may include modification or addition of equipment and devices, control strategies and/or software program. Corrective modifications made by Control Contractor during warranty period shall be incorporated and updated in Operation and Maintenance Manuals.

3.6 OWNER TRAINING

A. Provide minimum of 40 h of on-site training to Owner's representatives. Conduct training sessions during normal business hours after system start-up and acceptance by Owner. Scheduling of training session(s) will be established by Owner. Portions of training may be performed before system is completely operational, but no sooner than one month before system is planned to be fully operational. Final training session shall be held after systems are complete including all graphics programming.

B. Course content shall include, but not be limited to, the following topics:
1. Explanation of control sequences. Include which sensors are used and how output device operates.
2. Explanation of control drawings and manuals, including symbols, abbreviations, and overall organization.
3. Walk-through of Project to identify controller locations and general routing of network cabling.

4. Review of operation and maintenance of hardware devices including air compressor, air dryers, controllers, instruments, and sensors. Include schedule for routine maintenance.
5. Review of operation of operator's workstation; include hardware (PC's, printers, etc.).
6. Review of operator's workstation software using specific examples of operating hardware.
7. Review of portable operator's workstation software using specific examples of operating hardware.
8. Any additional item(s) specifically requested by Owner.

C. Provide listing of regularly scheduled factory classroom training sessions concerning advanced topics covering proper operation and maintenance of control systems, sensing, monitoring and control equipment. Additional classes travel and lodging will be arranged and paid by Owner.

D. Provide minimum of 8 h of additional on-site training to Owner's Representatives, 6 months after initial training is completed.

E. Scheduling of training session(s) will be established by Owner.

3.7 STARTUP

A. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.8 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

SECTION 23 09 02

CONTROL VALVES AND DAMPERS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 09 01 - Control Systems Integration

B. Section 23 09 93 - Control Sequences

C. Section 23 21 18 - Valves

D. Section 23 33 14 - Ductwork Specialties

E. Section 23 36 00 - Air Terminal Devices

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 GENERAL

A. No devices containing mercury will be allowed under this Specification.

1.4 SUBMITTALS

A. Product data sheets shall include construction materials and assembly methods, maximum design parameters (temperature, pressure, velocity, etc.), and performance data for full range of actuator stroke. Product data sheets shall include charts, graphics or similar items used in making selections, including damper to duct area ratio and free area ratio. Damper product data sheets shall indicate certified leakage rates for given pressure differentials.

B. Submit valve schedules with shop drawings, indicating unique tag numbers for each device, equipment item or system served, device model numbers, sizes, shut-off head required, actuator air pressure or force required to meet shut-off head, torque requirements for rotary valves, flow coefficients (Cv) for 10% and 100% valve stem travel, actual flow requirements based on equipment shop drawings, calculation of actual pressure drops, actuator model number, actuator torque capacities and pilot positioner locations.

C. Valve and damper Shop Drawing submittals will not be processed unless supporting data and sizing calculations are included.

D. Submit damper schedules with Shop Drawings, indicating unique tag numbers for each device, equipment or system served, device model numbers, duct sizes, damper sizes, flow rates, pressure differentials, calculation of actual damper pressure drops, approach velocities, leakage rates, torque requirements, actuator model number, actuator torque capacities and pilot positioner locations.

E. Select dampers to meet their intended service with respect to maximum approach velocities and maximum pressure differential. Damper materials shall match duct construction materials of systems in which they are installed (galvanized steel, aluminum, 304 or 316 stainless steel, etc.).

F. Aluminum dampers may be used in galvanized steel ductwork.

G. Warranty
   1. Provide 1 yr warranty on all materials and labor.
   2. Warranty requirements shall include furnishing and installing software upgrades issued by the manufacturer during the 1 yr warranty period.

1.5 VALVE SELECTION AND SIZING

A. General:
   1. Select control valves to meet their intended service without cavitation. Provide cavitation calculations for modulating globe control valves over 250°F and all modulating butterfly valves over 60°F.
   2. Select control valves and actuators for 100% shut-off against system maximum differential pressure.
   3. Valve body ratings indicated in Part 2 are minimum required. Valve body, trim and packing selected shall be designed to withstand maximum pressure and temperature encountered in system.
   4. Submit engineering calculations for sizing modulating control valves unless valves are scheduled. Control valves serving terminal devices may be sized based on flow ranges for each pump system.
   5. Shut-off and 2-position valves shall be full pipe size.
   6. Calculations for sizing modulating valves shall be based on actual characteristics of equipment and system in which valves are installed. Valve calculations shall include information such as pump head or available pressure.
   7. Control Contractor is responsible for obtaining adequate system information necessary for sizing.

B. Instrumentation Valves:
   1. Unless otherwise noted, instrumentation shut-off valves for isolation of gauges, switches, transmitters, etc., shall be as follows:
      a. Compressed air/instrumentation air systems: ball or plug-type valves
      b. Water systems: globe-type valves
      c. Steam and condensate systems: gate-type valves
      d. Ductwork, air handling unit or air terminal device penetrations: ball or plug-type valves
      e. Liquid line sampling valves: multiple turn, metering-type valves.

C. Water Valves:
   1. Select modulating control valves to provide 3-5 psi pressure drop at design flow rate with differential pressure less than 20 psi, and pressure drop equal to 25% of total pressure drop with differential pressure equal to or greater than 20 psi.
   2. Design criteria for sizing modulating valves shall be based on 2 port, normally open, equal percentage valves unless otherwise specified. Select heating and cooling coil control valves of major equipment including air handling units for minimum of 30-50% of equipment sub-circuit pressure drop, but not more than maximum available pump head allowing minimum 2 psi drop for balancing valve.
   3. Select control valves based upon pressure drop calculations and Cv values at 90% stroke.
   4. Size 3-way mixing or diverting valves not directly associated with pump subcircuit for 3-5 psi pressure drop.

5. Subcircuit is defined as branch supply and return piping to terminal device, including valve, coil, control valve, and balancing valve.

1.6 DAMPER SELECTION AND SIZING

A. Submit engineering calculations for sizing modulating control dampers including outside, return, and relief air dampers of air handling units unless dampers are scheduled.

B. Calculations for sizing dampers shall be based on actual characteristics of ductwork system being installed. Opposed blade dampers shall be sized for minimum of 10% of duct system pressure drop. Parallel blade dampers shall be sized for minimum of 30% of duct system pressure drop. Duct section is defined as ductwork containing flow control damper starting with inlet or branch tee and ending with outlet or branch tee. Calculate actual duct pressure drops for each duct section containing modulating damper using latest version of ASHRAE Handbook of Fundamentals. If control systems fixes pressure drop, use those pressure setpoints. Use balance damper to provide additional pressure drop as required for obtaining linear damper response.

C. Control Contractor is responsible for obtaining adequate system information necessary for sizing.

D. Two position dampers to be sized as close as possible to duct size, but in no case is damper size to be less than duct area.

E. Submit leakage and flow characteristic data for control dampers along with shop drawings. Leakage ratings shall be based on AMCA Standard 500 and dampers shall bear AMCA Air Leakage Seals.

PART 2 - PRODUCTS

2.1 CONTROL VALVES

A. General:
1. If control valves are not scheduled, refer to Part 1 of this Section for sizing criteria.
2. Use 2 or 3 port normally open globe type control valves with equal percentage contoured throttling plugs for steam and water applications, except as otherwise noted.
3. Butterfly valves may be used for water system control valves 5” and larger provided that valves meet pressure and temperature requirements. High performance butterfly valves shall be used for modulating applications. General purpose butterfly valves may be used for 2 position control.

B. Globe Valves (Commercial Grade):
1. Manufacturers: Honeywell, Johnson Controls, Siemens Building Technologies, or TAC
2. Valves shall be bronze or brass body, threaded ends for steel piping, solder ends for copper piping, 150 psi rating for 2” and smaller; iron body, bronze mounted, flanged, 125 psi rating for 2-1/2” and larger.
3. Valves shall have stainless steel stems, spring-loaded Teflon packing, with replaceable stem/plug and packing kits.

C. Characterized Ball Valves:
1. Belimo, Valve Solutions Inc., Bray Controls, Neles Controls or approved equal
2. Provide two-way or three-way modulating control valves as required.
3. Valves shall be ball-type valves with V-notch, segmented ball or characterizing disks for equal percentage flow response. Characterizing disks shall be securely fastened by a keyed ring or other securing device to prevent the disk from movement during operation.

4. Valves shall be forged bass body, NPT threaded ends, 150 psi rating for 2" and smaller. Valve bodies 2-1/2" and larger shall be carbon steel or cast iron.
5. Valves shall be furnished with stainless steel ball and stem with fiberglass reinforced Teflon (RTFE) seats and Viton, EPDM or RTFE O-rings and seals.
6. Actuators shall be spring return type for valves requiring fail position; floating control, or fail last position type for areas such as animal rooms, offices or conference rooms.
7. Actuators for major equipment such as air handling units, heating hot water or chilled water shall be fail-in-place, fail open, or fail closed depending upon service requirements. Size actuators to achieve system shutoff pressures.
8. Terminal control valves near the end of the reheat supply lines on each floor shall be 3-way diverting type valves to provide minimum flow through the supply mains.

D. General Purpose Butterfly Valves:
1. Refer to Section 23 2118 - Valves. Refer to Damper and Valve Actuators in this Section for valve actuators.

E. High Performance Butterfly Valves:
1. Manufacturers: DeZurik, Xomox, Jamesbury, Posi-Seal, Bray/McCannalok or Fisher
2. Carbon steel body, lugged style, ANSI Class 150, adjustable PTFE packing, PTFE seat with suitable metal back-up ring, upper and lower shaft thrust bearings, 316 stainless steel one piece shaft and 316 stainless steel disc with offset shaft/disc design.
3. Normal and dead end (without downstream flanging) pressure rating shall be 275 psi.
4. Provide pneumatic actuator and positioner. Provide limit switches as required.
5. Valves and actuators shall be manufactured by valve manufacturer. Valve assembly including actuator, positioner and limit switches if used shall be assembled by valve manufacturer.

F. Terminal Control Valves With Characterizing Disks (Reheat or Chilled Water):
1. Belimo, Johnson Controls, Siemens Building Technologies, Honeywell, TAC or approved equal
2. Provide two-way or three-way modulating control valves as required.
3. Valves shall be ball-type valves with characterizing disks for equal percentage flow response. Characterizing disks shall be securely fastened by a keyed ring to prevent the disk from movement.
4. Valves shall be forged bass body with nickel plating, NPT threaded ends, 150 psig rating for 2" and smaller.
5. Valves shall be furnished with stainless steel ball and stem, and fiberglass reinforced Teflon seats and seals.
6. Terminal control valves near the end of the reheat supply lines on each floor shall be 3-way diverting type valves to provide minimum flow through the supply mains.
7. Actuators shall be spring return type for valves requiring fail position, floating control with fail last position type for areas such as animal rooms, offices or conference rooms.
8. Manufacturer shall warranty components for period of 5 yrs from date of production, with first two yrs unconditional.

2.2 CONTROL DAMPERS

A. General:
1. If control damper sizes are not shown or scheduled, refer to Part 1 of this Section for sizing criteria.

2. Unless otherwise indicated, modulating control dampers shall be opposed blade or parallel blade type and 2-position (open/close) dampers shall be parallel blade type.
3. Blade linkage hardware shall have corrosion-resistant finish and be readily accessible for maintenance.
4. AMCA Leakage Classification of Control Dampers

Class	Static Pressure (Inches Water Column)			
	1	4	8	12
	Leakage Rate (cubic feet per minute)			
IA	3	-	-	-
I	4	8	11	14
II	10	20	28	35
III	40	80	112	140

B. Standard Modulating and Two Position Dampers (AMCA Leakage Class I and II):
1. Manufacturers and acceptable model numbers:
   a. Tamco 1500
   b. Johnson Controls VD-1330 (Double Piece)
   c. Honeywell D2
   d. Ruskin CD50/CD60
   e. Air Balance AC-525/526
2. Damper frames shall be minimum of 16 ga galvanized steel or 2.0 mm extruded aluminum. Blades shall be minimum of 16 ga galvanized steel or 14 ga aluminum. Blades shall have maximum blade width of 8” with steel trunnions mounted in bronze sleeve, nylon or ball bearings.
3. Furnish dampers with blade seal and side seals. Dampers and seals shall be suitable for maximum temperature, pressure differential and approach velocity to be encountered in system, but not less than temperature range of -40 to 200°F, pressure differential 6” WC, and approach velocity of 4000 fpm based on 4 ft. damper width.
4. Dampers, when closed, shall be guaranteed by manufacturer not to leak air in excess of 4 cfm per sq ft (Class I) to 50 L/s per m^2 at 0.25 kPa static pressure for 1220 mm x 1220 mm damper size.
5. Testing and ratings shall be per AMCA Standard 500-D.

2.3 SMOKE DAMPERS

A. Refer to Section 23 3314 - Ductwork Specialties, for Smoke Damper Specification.

2.4 DAMPER AND VALVE ACTUATORS

A. Analog Electronic:
1. Manufacturers: Belimo, Honeywell, Johnson Controls, Siemens Building Technologies or TAC
2. Actuators shall be electric motor/gear drives that respond proportionally to analog voltage or current input, or digital floating control signals.
   a. Floating control actuators shall only be used for terminal hot water or chilled water control.
   b. Analog control actuators shall be used for all other modulating applications.
3. Stroke time for major equipment shall be 90 seconds or less for 90° rotation. Stroke time for terminal equipment shall be compatible with associated local controller, but no more than 6 minutes.

4. Provide spring return feature for fail open or closed positions, as required by control sequence, for critical applications such as outside, return, or exhaust dampers, heating and cooling coils on major air handling units, humidifiers, heat exchangers, flow control for major equipment items such as chillers, cooling towers, boilers, etc. Fail-last-position actuators do not have spring return feature.
5. Provide position feedback potentiometers connected to controller for closed loop control on major equipment analog control loops.
6. Actuators for terminal heating/cooling equipment do not require spring return feature.

B. Discrete Two-Position Electric:
1. Manufacturers: Belimo, Honeywell, Johnson Controls, Siemens Building Technologies or TAC
2. Actuators shall be electric motor/gear drives for two-position control. Stroke time shall be 90 seconds or less for 90° rotation.
3. Provide spring return feature for fail open or closed positions as required by control sequence. Fail-last-position actuators do not have spring return feature.

PART 3 - EXECUTION

3.1 CONTROL VALVES

A. Furnish control valves as shown on drawings and/or as required to perform control sequences specified.

B. Control valves furnished by Control Contractor shall be installed by Mechanical Contractor under coordinating control and supervision of Control Contractor.

C. Increaser and decreaser fittings required to facilitate valve installations shall be provided by Mechanical Contractor.

3.2 CONTROL DAMPERS

A. Furnish control dampers as shown on drawings and/or as required to perform control sequences specified, except those furnished with other equipment.

B. Control dampers furnished by Control Contractor shall be installed by Mechanical Contractor under coordinating control and supervision of Control Contractor.

C. Blank-off plates or transitions required to facilitate dampers shall be provided by Mechanical Contractor.

D. Furnish interconnecting hardware, linkages, etc. for installation of multiple section dampers.

3.3 SMOKE DAMPERS

A. Refer to Section 23 3314 - Ductwork Specialties

3.4 ACTUATORS AND PILOT POSITIONERS

A. Provide actuator for each automatic damper or valve with sufficient capacity to operate damper or valve under all conditions. Select actuators to provide tight shut-off against maximum system temperatures and pressure encountered. Each actuator shall be full-modulating or two-position type as required or specified, and shall be provided with spring-return for fail open or fail closed position for fire, freeze, moisture, occupant safety, equipment protection, heating or cooling system protection on power interruption as indicated and/or as required. Smoke dampers and steam valves serving pressure rated heat exchangers or convertors shall fail-closed.

B. Valve and damper operating speeds shall be selected or adjusted so that actuators will remain in step with controllers without hunting, regardless of load variations. Actuators acting in sequence with other actuators shall have adjustment of control sequence as required by operating characteristics of system.

C. Provide proper linkage and brackets for mounting and attaching actuators to devices. Design mounting and/or support to provide no more than 5% hysteresis in either direction (actual movement of valve stem or damper shaft versus ideal movement) due to deflection of actuator mounting.

D. Position feedback potentiometers shall be provided where floating control actuators are sequenced with other floating control actuators in terminal hot water control (i.e., reheat valve, fin tube radiator valve, radiant ceiling panel valve, etc.).

E. Calibrate position feedback potentiometers, where specified, with range and gain factors as required for proper operation per manufacturer's recommendations.

3.5 STARTUP

A. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.6 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority

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SECTION 23 09 03

CONTROL INSTRUMENTATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 09 01 - Control Systems Integration

B. Section 23 09 05 - Instrument Point List

C. Section 23 09 93 - Control Sequences

D. Section 23 21 20 - Piping Specialties

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 SUBMITTALS

A. Devices shall be indexed by bill of material for each system as detailed in Section 23 0901 - Control Systems Integration.

B. Thermostat/Room Temperature Sensor Schedules:

1. Submit thermostat/room temperature sensor schedule with shop drawings. Thermostat/room temperature sensor schedule shall have detailed listing of which type is used for each room, including data concerning service and model numbers, sizes, cover types, and engineering data sheets for each control device.

1.4 FCC COMPLIANCE

A. Digital equipment furnished under this Contract shall be tested and made to comply with limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environments. Literature shall so note and equipment shall be so labeled.

PART 2 - PRODUCTS

2.1 GENERAL

A. Pressure and temperature ratings of devices indicated in Part 2 - of this Section are minimum required. Devices shall be designed to withstand maximum pressures and temperatures encountered in respective systems.

B. No devices containing mercury will be allowed under this Specification.

2.2 GENERAL INSTRUMENTATION

A. Pressure Gauges:
   1. Refer to Section 23 2120 - Piping Specialties

B. Thermometers (Dial-Type):
   1. Refer to Section 23 2120 - Piping Specialties

2.3 DISCRETE ELECTRIC INSTRUMENTATION

A. General:
   1. Electrical devices, switches, and relays shall be UL listed and of type meeting current and voltage characteristics of project. Terminal connections shall be made at terminal blocks inside of NEMA 1 enclosures unless otherwise specified. Outdoor units shall be NEMA 4 with concealed adjustment.
   2. Ratings of normally open and normally closed contacts shall be adequate for applied load (minimum 5 amps at 240 Volts).
   3. Accuracy of devices shall be ± 1% of scale with adjustable offset unless otherwise specified.

B. Temperature Switches (Electric Thermostats):
   1. Line voltage or low voltage type suitable for application with adjustable setpoint and setpoint indication.
   2. Low voltage type to have heat anticipation.
   3. Thermostats with remote sensing bulb shall have liquid filled sensing element and exposed setpoint adjustment.
   4. Wall mounted space thermostat enclosure shall have concealed sensing element and exposed setpoint adjustment.
   5. Unless otherwise stated, space thermostat covers shall be manufacturer's standard plastic.

C. Temperature Low Limit Switches (Freezestats):
   1. Electric 2 position type with temperature sensing element and manual reset. Controls shall be capable of opening circuit if any 1 foot length of sensing element is subject to temperature below setting.
   2. Sensing element shall not be less than one lineal foot per square foot of coil surface areas. Unless otherwise indicated, calibrate temperature switch setpoint to 38°F.

D. Temperature Switches (Aquastats):
   1. Electric 2-position type with strap-on or immersion temperature sensing element. Switch contacts close on increasing temperature to provide start signal for unit heaters, cabinet unit heaters and open on high limit control for heating hot water heat exchangers.
   2. Sensing element shall be set for 100°F (FA) for unit heater control. For setpoints to aquastats for hot water heat exchangers, refer to control sequences for each hot water system. Provide screw-type terminals in NEMA 12 switch enclosure for field mounting at unit heaters.

E. Relays:
   1. Manufacturers: IDEC, Potter Brumfield, Square D, or Allen Bradley
   2. Equal to IDEC type RH2B-U, miniature 8 blade pilot relay with DPDT silver cadmium oxide contacts rated at 10A, 30 VDC, or 120 VAC. Coil shall match control circuit characteristics. DDC outputs shall be 24 VDC with maximum current burden of 50 milliamps. Rectangular base socket mount with blade type plug-in terminals and polycarbonate dust cover.
   3. Provide DIN rail mountable (Snap type) mounting sockets equal to IDEC SH2B-05.

F. Enclosed Relay (Relay-in-a-Box):

1. Manufacturers: Veris Industries, Kele & Associates, Functional devices, Inc. or approved equal.
2. 1 or 2 SPDT relays in NEMA 1 or better enclosure. Coil shall be selected for control circuit characteristics.
3. Contacts rated at 10A, 28 VDC or 120 VAC. Conduit nipple is 15 mm NPT. Maximum coil current burden 50 milliamps.

G. Pressure Differential Switches (Air Systems):

1. Manufacturers: Cleveland Controls, Dwyer, Honeywell, Johnson Controls/Penn, Siemens Building Technologies, or TAC.
2. Adjustable set point, differential pressure type. Select switches for accuracy, ranges (20 to 80% of operating range) and dead-band to match process conditions, electrical requirements and to implement intended functions.
3. Pressure differential switches for air systems shall have pressure rating of at least 2.5 kPa.
4. Pressure indicating differential switches for air systems shall be equal to Dwyer Series 3000 photohelic gauge.
   a. Maximum Temperature Rating: 82°C
   b. Repeatability: ± 1%

H. Pressure Differential Switches (Water Systems):

1. Manufacturers: Allen Bradley, Ashcroft, Dwyer, Honeywell, Johnson Controls/Penn, Siemens Building Technologies, TAC, SOR, or United Electric.
2. Adjustable set point, differential pressure type. Select switches for accuracy, ranges (20 to 80% of operating range) and dead-band to match process conditions, electrical requirements and to implement intended functions.
3. Pressure differential switches for water systems shall be rated for 1035 kPa unless otherwise noted. Chilled water pressure differential switches shall be provided with totally sealed vapor tight switch enclosure on 2070 kPa body. Differential pressure switches to have 3-valve manifold for servicing.
   a. Maximum Temperature Rating: 149°C
   b. Repeatability: ± 1%

I. Position Switches (End Switches):

1. Manufacturers: Allen Bradley, Johnson Controls/Penn, Honeywell, Ruskin, Greystone Energy Systems, Reed National Air Products, NAMCO, Omron or Westlock.
2. Provide damper position switches, as required to meet specified sequence. Rotary switches shall be cam action, lever, or proximity type. Provide damper brackets and connecting rods for connecting position switch actuation levers to damper blades or jackshafts.
3. "Tip Switches" or other position switches that contain mercury shall not be used for damper end switch applications.

J. Current Switches - Constant Load, Constant Speed:

1. Manufacturers: Veris Industries, N-K Technologies, Absolute Process Instruments, Kele & Associates, R-K Electronics or approved equal.
2. These shall be Induction type sensors clamped over single phase conductor of AC electrical power and shall be solid-state sensors with adjustable threshold and normally open contacts. Each current switch shall be selected for proper operating range of current.
   a. Output: Solid state relay or relay contacts
   b. Trip Setpoint: Adjustable by multi-turn potentiometer
   c. Operating Temperature: 0 to 55°C
   d. Response Time: < 0.5 seconds

K. Fume Hood Monitoring System:
   1. Manufacturers: Siemens Building Technologies, Tek-Air, TSI, Flow Safe, Inc., Alnor, or Phoenix.
   2. Provide local panel mounted on each fume hood with visual and audible indication of face velocity, normal flow (green), low flow warning (yellow indication), and low-low flow alarm (red).
   3. Face velocity indication shall read in feet per minute and shall be either 2" analog indicator type or ½" digital readout.
   4. Audible alarm shall sound during low-low flow alarm conditions. Provide alarm silence switch.
   5. Face velocity shall be calculated based on velocity through through-wall type sensor.

L. Oxygen Depletion Monitoring System:
   1. Manufacturers: Toxalert, OI Analytical Corporation, MDA Scientific, MSA, Vulcain or approved alternate.
   2. Provide oxygen depletion monitoring systems as listed below. Each system shall be complete package with remote or local space sensors, detection instruments, alarm contacts, local indication of current measured value for each sensor and status indicator lights for power and status of each sensor. Devices not requiring remote mounting shall be housed in metal control panel. Status indicators shall be mounted on panel faceplate.
   3. Provide quantity of sensors required for full space coverage per manufacturers recommendations.
   4. Monitoring panel shall be located as shown on plans.
   5. Provide panel mounted alarm horn with silence switch.
   6. Sensor life shall be a minimum of one year.
   7. Units shall have adjustable setpoints and self-test diagnostics.
      a. Warning Setpoint: 19.5 %LEL
      b. Alarm Setpoint: 16 %
      c. Output: 4-20 mA DC
      d. Alarm Relays: 3 Amps, 120 VAC (1 Warning relay and 1 Alarm relay)
      e. Range: 0-25% O2
      f. Remote Sensor: Electrochemical O2 Sensor
      g. Installation: 18" A.F.F.

M. Tornado Shelter Exhaust Fan Control Station with Pilot Light:
   1. Manufacturers: Allen Bradley, IDEC, Square D, or approved alternate.
   2. Heavy-duty nonilluminated 120 VAC/60 Hz 10A continuous selector switch with same NEMA rating as panel enclosure shall be used for control panel operator interface switching.
   3. Heavy-duty illuminating pilot light with same NEMA rating as panel enclosure shall be used for operator interface indication. Include power module to match control system voltage to lamp.
      a. Contact Type: Contractor shall select based on drawings or as required to meet intended control function.
      b. Lamp Type: Red High Visibility LED
      c. Voltage: 120 VAC/60 Hz or 24 VAC unless otherwise noted. (Contractor to match to required application.)
      d. Current: 5 amp continuous.
      e. Mechanical Switch Actuation Life: 500,000 cycles minimum.

N. Cooling Coil Drain Pan Moisture Detector:
   1. Manufacturers: Kele and Associates, Gems Sensors or approved alternate.

2. Moisture detector is small, electronic control relay for detecting rising water levels, within drain pans or other containments. Moisture detector shall alarm when water levels reach 0.43" to prevent damage from overflow of drain pans. Relay shall reset when water levels decrease to 0.31" and relay re-energizes.
3. Relay is normally energized upon powering up and no water is present. When water level reaches the trip point the relay de-energizes for alarming in BAS.
4. Moisture Detector Relay Module (Model LD1-24):
   a. Supply Voltage: 24 VAC, 60 Hz
   b. Power Consumption: 1 W
   c. Cable length: 18"
   d. Relays Contacts:
      1). Type: SPDT
      2). Rating: 2.5A at 24 VDC; 5.0A at 120 VAC
   e. Enclosure Rating: Hermetically Sealed
   f. Dimensions: 0.87" H x 2.0" W x 1.25" L

2.4 ANALOG ELECTRONIC INSTRUMENTATION

A. Space Temperature Sensors:
1. Manufacturers: BAPI, Minco or approved alternate
2. Sensors shall be platinum RTD type, with the following minimum performance:
   a. Temperature Coefficient of Resistivity (TCR): 0.00385 ohm/ohm/°C
   b. Accuracy: ± 0.1% at 32°F (Class B)
   c. Conformance: DIN-IEC 751
   d. Operating Range: -50 to 500°F, 0 to 99% rh
3. Thermistors will be acceptable in lieu of RTD provided thermistor carries 5 yr guarantee that device will maintain its accuracy within tolerance of ± 0.36°F between 32°F and 32°F, and -0.5°F between 20°F and 212°F.
4. Unless otherwise stated, space sensor cover shall be manufacturer's standard plastic cover.
5. Provide visible setpoint, set point adjustment, occupancy override pushbutton and space temperature indication for all locations except for the following:
   a. Corridors
   b. Lobbies
   c. Toilet Rooms
   d. Storage Rooms
   e. Mechanical Rooms
   f. Electrical Rooms
   g. Elevator Equipment Rooms

B. Duct Mounted or Insertion Temperature Sensors:
1. Platinum RTD type, with the following minimum performance:
   a. Temperature Coefficient: 0.00385 ohm/ohm/°C
   b. Accuracy: ± 0.12% at 32°F (Class B)
   c. Conformance: DIN-IEC 751
   d. Operating Range: -50 to 170°F, 0 to 99% rh
2. Install insertions sensors in stainless steel probes or wells.
   a. Insertion sensors shall have solar powered LCD display.

3. Outside air sensors shall be weatherproof of noncorrosive construction and protected with solar shield. Mount outside air sensors on north side of building or in area intake wells for air handling systems to avoid thermal effects from direct sunlight.
4. Sensors mounted in air streams, such as air handling units, supply ducts, exhaust ducts or return ducts, shall be averaging type. Mount averaging sensor across duct area in a "Z" pattern using mounting clips specific for averaging temperature sensor probes.
5. Thermistors will be acceptable in lieu of RTD provided thermistor carries 5 year guarantee that the device will maintain its accuracy within a tolerance of ± 0.36°F between 32°F and 32°F, and 0.5°F between --20°F and 212°F.
6. Temperature sensors shall be provide with integral junction box.

C. RTD Temperature Sensor (Water Systems):
1. Manufacturers: Rosemount, Burns, Minco Products, Weed, Pyromation or approved alternate
2. These shall be 100Ω platinum RTD type temperature instruments for process immersion
   a. Temperature Coefficient: 0.00385 ohm/ohm/°C
   b. Accuracy: ± 0.12% at 32°F (Class B)
   c. Conformance: DIN-IEC 751
   d. Operating Range: -50 to 170°F, 0 to 99% rh
   e. Thermowells: By same manufacturer as Sensor/Transmitter or approved alternate. Length shall be such that well, containing sensor, projects into process fluid from 2" to 2.5" beyond pipe wall when installed.

D. Space Humidity Sensors/Transmitters:
1. Manufacturers: Vaisala, General Eastern, Automation Components Inc., Veris Industries, or Minco.
2. Space humidity sensors shall be wall mount type with brushed aluminum or brushed nickel cover to match room thermostats and/or temperature sensors.
3. Sensing element shall be resistive bulk polymer, or thin film capacitive type. Sensor/transmitter shall have the following minimum performance:
   a. Accuracy: ± 2% rh at 25°C over range of 20-95% rh including hysteresis, linearity and repeatability
   b. Temperature Effect: Less than 0.06% per °F at baseline of 68°F
   c. Sensitivity: 0.1% rh
   d. Repeatability: 0.5% rh
   e. Hysteresis: Less than 1%
   f. Long Term Stability: Less than 1% rh drift per year
   g. Adjustment: ± 20% rh zero, non-interactive
      ± 10% rh span, non-interactive
   h. Operating Range: 0-99% rh, non-condensing, sensor
      0-95% rh, non-condensing, electronics
   i. Output: 4-20 mA, 0-100% linear, proportional
   j. Power: 12-36 VDC

E. Duct Mounted Humidity Sensors/Transmitters:
1. Manufacturers: Vaisala, General Eastern, Automation Components Inc., Veris Industries or, Minco.
2. Probe type, temperature compensated, resistive bulk polymer or thin film capacitive type. Sensor/transmitter shall have the following minimum performance.

a. Accuracy: ± 2% rh at 25°C over 20-95% rh including hysteresis, linearity and repeatability
b. Temperature Effect: Less than 0.06% per °F at baseline of 68°F.
c. Sensitivity: 0.1% rh
d. Repeatability: 0.5% rh
e. Hysteresis: Less than 1%
f. Long Term Stability: Less than 1% drift per year
g. Adjustment: ± 20% rh zero, non-interactive
   ± 10% rh span, non-interactive
h. Operating Range: 0-99% rh, non-condensing, sensor
   0-95% rh, non-condensing, electronics
i. Output: 4-20 mA, 0-100% linear, proportional
j. Power: 12-36 VDC

F. Combination Temperature/Humidity Transmitter:
1. Manufacturers: Vaisala, Automation Components Inc., Veris Industries, Minco or General Eastern.
2. Combination Temperature and Humidity sensor/transmitter shall meet the following minimum requirements:
3. Temperature:
   a. Temperature Sensor: 100 or 1000 Ohm Pt RTD
   b. Temperature Coefficient: .00385 ohm/ohm/°C
   c. Accuracy: Standard ±0.1% of Span
      Class A ±0.05°f
   d. Operating Range: -10 to 160°F
   e. Supply Voltage: 18 to 36 VDC / VAC
   f. Output Ranges: 2-wire, 4 to 20 mA or 3-wire, 0 to 5, 0 to 10 VDC or 4 to 20 mA (24 VAC)
4. Humidity:
   a. Temperature Compensated: Full range of rh signal
   b. Response Time: 30 seconds for 63% step
   c. Accuracy Range: ±2% rh between 20 to 95% rh Span (including hysteresis, linearity repeatability).
   d. Sensing Element: Resistance or Capacitance humidity sensor
   e. Operating rh Range: 0 to 100% rh(non-condensing)
   f. Supply Voltage: 24 VDC (current or voltage output) 24 VAC (contact factory)
   g. Output Ranges: 4 to 20mA, 0 to 5V, 0 to 10V
   h. Long Term Stability: Less than 2% rh drift per year
5. Enclosure shall be made of ABS Plastic or equivalent and include an optional LCD display on face of enclosure.
6. Optional LCD readout shall be capable of °C or °F operation with an adjustable display toggle switch to change from temperature to humidity display. Unit shall include capability of temperature and humidity setpoint value display during adjustment.

G. Ducted Air System Static Pressure and Differential Pressure (Velocity) Transmitters:
1. Manufacturers: GE Modus, Setra, Ashcroft XLDP or approved equal.

2. Provide transducers/transmitters to convert velocity pressure differential or static duct pressure relative to sensor location into electronic signal.
3. Unit shall be capable of transmitting linear 4 - 20 mA DC output signal proportional to differential (total minus static or static minus ambient) pressure input signals with the following minimum performance and application criteria:
   a. Span: Not greater than twice duct static or velocity pressure at maximum flow rate, or more than 16 times velocity pressure at minimum flow rate.
   b. Accuracy: ± 1.0% of span or ± 1.0% of full scale
   c. Dead Band: Less than 0.5% of output
   d. Hysteresis: Within 0.5% of span or within 0.5% of full scale
   e. Linearity: Within 1.0% of span or within 0.5% of full scale
   f. Repeatability: Within 0.5% of output
   g. Response: Less than 1 second for full span input
4. Return and exhaust air system static pressure transducers/transmitters shall be furnished with protective integral air filters on pressure sensing lines from static pressure sensing stations and with static air probes to prevent migration of moisture and particulate matter into transducers. If inputs to pressure transducers/transmitters are dead-ended, integral air filters are not required. Supply air system sensors do not require integral air filters.

H. Transient Time Ultrasonic Flow Meter:
1. Manufacturer: Siemens SITRANS, Flexim, Dynasonics or approved alternate.
2. These shall be transient time ultrasonic type flow meters to provide linear output signal proportional to flow rate.
3. Sensor Mounting: Strap-on to pipe
4. Strap Material: Stainless Steel
5. Converter Mounting: Remote
6. Process Temperature Limits: 0°F to 300°F (-17°C to 150°C)
7. Performance:
   a. Accuracy: Error ± 1.5%
   b. Repeatability: Error ± 0.5%
8. Maximum Entrained Gas: 0.75% minimum
9. Maximum Turbidity: 7500 ppm minimum
10. Power Requirements: 120VAC / 60 Hz
11. Minimum Turn-Down: 10 to 1 of full scale
12. Minimum Enclosure Rating NEMA 4
13. Output: 4-20 mA DC current
14. Options:
   a. Remote Indication: Provide digital LCD 3 digit minimum if meter installed higher than 5’6” AFF.
15. Calibration Shift and Ambient Effects:
   a. Position: Transmitter shall operate in any position.
   b. Vibration: Transmitter shall not be affected by industry normal piping vibration when operating within its normal range.
   c. Ambient Temperature: Transmitter shall not be in error more than 1.0 percent of span over change in ambient temperature of 100°F.

I. Thermal Dispersion Air Flow Measurement Sensor/Transmitter:

1. Manufacturers: Ebtron or approved equal.
2. Duct Mounted Flow Sensor:
   a. Multi-probe type thermal dispersion flow sensing station consisting of aluminum probe assembly with flanged connection and multiple hermetically sealed sensors in glass-filled polypropylene housing. Arrangement of sensors along probe assembly factory set to perform equal area traverse of duct cross section.
   b. Flow Sensor:
      1). Accuracy: ± 2% of reading
      2). Repeatability: ±0.25% of reading
      3). Materials: Probe – Aluminum
      4). Sensor Housing – Glass-Filled Polypropylene
      5). Mounting Brackets – 304 SS
      6). Calibrated Range: 0 – 5,000 fpm
   c. Temperature Sensor:
      1). Accuracy: ± 0.15%
      2). Sensor Temperature Range: -20°F to 160°F (0 – 1,500 fpm); 30°F to 160°F (>1,500 fpm)
      3). Humidity Range: 0 – 99%, non-condensing
      4). Probe Size Range: 8” to 120”
   d. Transmitter:
      1). Power Requirements: 24 VAC (22.5 to 29 VAC).
      2). Enclosure: Aluminum Housing
      3). Outputs: 0-10VDC or 4 to 20 mADC
      4). Output Resolution: 0.025% of selected range
         a). Output 1: Airflow (0 – 5,000 fpm)
         b). Output 2: Temperature (-20°F to 160°F)
      5). Ambient Temperature: -20°F to 120°F

J. Current Transformers:
1. Manufacturers: General Electric, Square D, Kele & Associates, N-K Technologies or Veris Industries.
2. Alternating current transformers shall conform to latest applicable Standards including AEIC, EEI-NEMA, Standards for Instrument Transformers (MSJ-11) and ANSI Standard C57.13 for instrument transformers.
   a. Rated Voltage: 480 V
   b. Insulation Class: 600 V
   c. Basic Impulse Level: 60 Hz
   d. Short Time Current Rating: 100% (1 second)
   e. Accuracy Class: 0.3
   f. Continuous Current Rating: 150%

K. P-E Transducers (Pressure Transmitters):
1. Manufacturers: Ashcroft, Mamac, Setra, Kele & Associates or GE Modus
2. Units shall have the following characteristics:
   a. Input: Pressure 0-15 psig, minimum
   b. Output Signal: 4-20 mA, 0-5 VDC, 1-5 VDC, 1-10 VDC

c. Accuracy: 1% of span
d. Operating Temperature 32 to 125°F
e. Power Requirements: 24 VDC (10-30 VDC)

PART 3 - EXECUTION

3.1 GENERAL

A. Install control equipment, wiring and air piping in neat and workmanlike manner and in accordance with manufacturer's recommendations. Maintain clearances, straight length distances, etc., required for proper operation of each device. Mark and detail on coordination drawings, exact locations of inline devices, wells, and taps to be installed by Mechanical Contractor.

B. Coordinate timely delivery of materials and supervise activities of other trade Contractors to install inline devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, and other such items furnished by Control Contractor which are to be installed by Mechanical Contractor.

C. Install control devices in accessible location.

D. Mount motor control devices within 5 ft. of disconnect switch, or starting device furnished by Electrical Contractor unless noted otherwise. Maintain required NEC clearances.

E. Control Contractor and Mechanical Contractor shall review proposed static pressure sensor and flow meter locations with Laboratory and Engineer for approval prior to installation.

3.2 GENERAL INSTRUMENTATION

A. Pressure Gauges (Pressure Indicators):
1. Install pressure gauge for indication of supply and control pressure in pneumatic systems at output of controllers, I/P transducers, electric air solenoid valves, pressure switches and other points where visible indication of air pressure is required for operating and maintenance purposes.
2. Provide test port for quick connection of test gauges at valve, damper motor and other actuator branch lines.
3. Pressure gauge tapings in piping will be provided by Mechanical Contractor.

B. Thermometers (Temperature Indicators):
1. Install thermometers at each point of temperature transmission and control, except for those that are indicated at local control panels. Install thermometers to permit easy reading from floor or operating platform (within 3 ft. of line of sight). Provide remote bulb thermometers with readout indicators mounted within 3 ft. of line of sight whenever sensing point is more than 3 ft. from line of sight.
2. Thermometer wells in piping will be installed by Mechanical Contractor.

C. Local Control Panels:
1. Install remote mounted devices, controllers, I/O terminal blocks, power supplies, etc., inside of local control panels.
2. Locate panels as shown on drawings.
3. Locate panels adjacent to equipment served with minimum of 3 ft. clearance in front of door. Provide sufficient clearances to allow full door swing and full access to internal components. Submit proposed panel locations with shop drawing submittals.
4. Mount top of panels between 5 and 6 ft above floor so that gauges and indicators are at eye level.

3.3 DISCRETE AND ANALOG INSTRUMENTATION

A. Wall Mounted Space Thermostats/Temperature Sensors:

1. Install space thermostats/sensors where indicated, as required to perform specified control sequences, and as directed to meet job site conditions.
2. Mount space thermostats/sensors at 5 ft. above floor unless otherwise indicated.
3. Mount space thermostats/sensors with accessible setpoint adjustment or temperature reading (thermometer or digital temperature readout) at 4 ft. above floor.
4. Space thermostats/sensors located on exterior walls shall be mounted on thermally insulated sub-base.
5. Relocate space thermostats/sensors if required due to draft, interferences with cabinets, chalkboards, etc., or improper sensing.
6. Mount space thermostats/sensors in corridors, stairways and public toilets 7 ft above floor.

B. RTD Temperature Transmitters:

1. Provide RTD temperature transmitters whenever DDCPs cannot receive RTD type inputs.

C. Low Limit Temperature Switches (Freeze Stats):

1. Install low limit controls where indicated on drawings or as specified. Unless otherwise indicated, install sensing element on upstream face of cooling coil where cooling coil is provided, or at downstream side of heating coils where no cooling coil is provided.
2. Distribute sensing element across entire area of medium being sensed. Install controls at accessible location with suitable mounting brackets and element duct collars where required.

D. Static Pressure and Air Flow Stations:

1. Furnish static pressure and air flow measuring stations to Mechanical Contractor for installation.
2. Stations shall be installed in strict accordance with manufacturer's published requirements. These stations serve as primary signals for airflow control systems; therefore it shall be responsibility of Control Contractor to verify location and installation to assure that accurate primary signals are obtained.

E. Outside Air Temperature Sensors:

1. Mount on north side of building or in intake area wells for air handling systems. Provide solar shields for installations where sensors may be exposed to sunlight conditions.

F. Water Flow Meters:

1. Install flow measuring devices with recommended straight pipe diameters upstream and downstream of elbows, tees, valves, or other fittings that cause uneven turbulent flow conditions.
2. If no recommendations are given, provide straight pipe equal to 10 pipe diameters upstream and 5 pipe diameters downstream.

G. Sensor Wells:

1. Wells mounted in pipe 3” and larger may be installed in horizontal or vertical lines provided that element is always in flow, (for condensate and other gravity return lines, install in bottom of pipe). Wells mounted in pipe 2-1/2” and smaller shall be installed at elbow tee fittings with well pointed upstream. Minimum of 2” pipe size for elbow tee installation.

H. Transmitters, Indicators, and Transducers:

1. Locate transmitters at sensing devices or within 100 ft of remote mounted transmitters. For hot systems (150°F and higher) mount electronics on side of pipe or remotely mount. For indicating type instruments, locate indicating element within 6 ft of floor with readout easily visible from floor level. Provide remote readouts if necessary.

2. Provide pressure transducers integral to DDC panels or separate components to convert digital analog signals to variable pneumatic air pressure signals.
3. Provide P-E transducers to convert analog pressure signals to analog electronic signals for input to DDC panels.

3.4 STARTUP

A. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Building Systems Commissioning.

3.5 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

SECTION 23 09 05

DDC POINT SCHEDULE

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 09 01 – Control Systems Integration.

B. Section 23 09 02 – Control Valves and Dampers

C. Section 23 09 03 – Control Instrumentation

D. Section 23 09 23 – Direct Digital Controllers and Networks

E. Section 23 09 93 – Control Sequences

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 SUBMITTALS

A. Point List:

1. Submittals shall include list of each control input and output, device it is controlling, locations of device, and symbol or label of control point in software.
2. The points listed on the attached “Instrument Point List” are not all inclusive. In addition to the points listed, include those points required to implement and monitor the features described in the control sequences.

1.4 INSTRUMENT OR DEVICES USED FOR POINT INPUT TO BAS.

A. Control Contractor shall be responsible for providing necessary point input to BAS for equipment and systems provided by Mechanical Contractor or Control Contractor not covered in sequences of operation but necessary for operation of those systems or equipment.

B. Instrument or devices such as auxiliary contacts of equipment provided by other than Mechanical Contractor or Control Contractor, will be furnished with the equipment unless otherwise indicated.

1.5 ANALOG ALARM POINTS

A. Unless indicated in Section 23 0993, consult Laboratory for the specific values to be used for High and Low limit alarms during programming.

PART 2 - PRODUCTS

2.1 NOT APPLICABLE TO THIS SECTION.

PART 3 - EXECUTION

3.1 NOT APPLICABLE TO THIS SECTION.

End of Section

Affiliated Engineers

SYSTEM:

HVAC SYSTEMS

POINT DESCRIPTION	HARDWARE																											SOFTWARE																				
	OUTPUT (O)							INPUT (T, D, V, C)																				ALARMS										BAS FUNCTIONS												
	DIGITAL				ANALOG			DIGITAL										ANALOG										DIGITAL						ANALOG																
	Control Relay	Solenoid	Contactor (Start/Stop)	Floating Point (Triac)	Pneumatic Transducer	4-20mA, 2-10VDC, etc.	Electrical Transducer	Pressure Switch	Flow Switch	Temperature Switch	Humidity Switch	Switch Closure/Opening	Auxiliary Contact	Level Switch	Vibration Switch	Current Switch	Flow Totalizer (Pulse)	Temperature	Relative Humidity	PSIG, PSIA, PSID	Position	Flow	Level	Speed	Conductivity	KW	Misc	Equipment Fault	Equipment Status	Equipment HOA	Maintenance	Open/Closed	Critical	High Limit	High-High Limit	Low Limit	Low-Low Limit	Run Time Totalization	Scheduled Start/Stop	Totalization	Occupancy Reset	CO2 Reset	Day/Night Setback	Economizer	Temperature Control	Reheat Coil Reset	Hot Water OA Reset	Chilled Water Reset	Condenser Water Reset	Lead/Lag Control	LEED M&V	Integrated Communication	Comments
GENERAL																																																			
Outside Air Temperature																		X																															X		
Outside Air Humidity																			X																														X		
PLUMBING SYSTEM																																																			
Building Incoming Domestic Water Flow																	X																						X										X		
Building Incoming Domestic Water Usage - Daily Total (Gal)																																							X												
Building Incoming Domestic Water Usage - Monthly Total (Gal)																																							X												
Building Incoming Domestic Water Usage - Yearly Total (Gal)																																							X												
Building Incoming Natural Gas Flow																	X																						X										X		
Building Incoming Natural Gas Usage - Daily Total (Cu. Ft.)																																							X												
Building Incoming Natural Gas Usage - Monthly Total (Cu. Ft.)																																							X												
Building Incoming Natural Gas Usage - Yearly Total (Cu. Ft.)																																							X												
Air Compressor - Alarm (Typical of 2)												X																X																								
Air Compressor - Run Status (Typical of 2)												X																	X									X														
Air Drier - Alarm (Typical of 2)												X																X																								
Lab Vacuum System - Alarm												X																X																								
RO Water System - Alarm												X																X																								
Lab Gas Manifold - Switchover Alarm (Typical of 6)												X																	X																							
Elevator Sump Pump - High Level Alarm												X																X																								
Sewer Lift Station (Typical of 2)																																																			
Common Alarm												X																X																								
Common Pump Fail Alarm												X																X																								
Valve Vault Flood Alarm												X																X																								
Transducer-Fail Alarm												X																X																								
High Wet-Well Level Alarm												X																				X																				
Low Wet-Well Level Alarm												X																X																								
Power-Fail Alarm												X																				X																				
ELECTRICAL SYSTEMS																																																			
Transfer Switch (Normal Power Indication)													X																																						
Transfer Switch (Emergency Power Indication)													X																																						
Emergency Egress Lighting UPS - Fault (Typical of 5)													X															X																								
Power Monitoring System:																																																			
Main Incoming Power, 1N-GH1 - Real Power (kW)																																							X										X	X	
Main Incoming Power, 1N-GH1 - Power Consumption (kWh)																													X																				X	X	
Standby/EM Dist Panel, PS-DH1 - Real Power (kW)																																							X										X	X	
Standby/EM Dist Panel, PS-DH1 - Power Consumption (kWh)																													X																				X	X	
Office Distribution Panel, 1N-DL3 - Real Power (kW)																																							X										X	X	
Office Distribution Panel, 1N-DL3 - Power Consumption (kWh)																													X																				X	X	
Floor Lab Distribution Panel, 1N-DL1 - Real Power (kW)																																							X										X	X	
Floor Lab Distribution Panel, 1N-DL1 - Power Consumption (kWh)																													X																				X	X	
Floor Lab Distribution Panel, 1N-DL2 - Real Power (kW)																																							X										X	X	
Floor Lab Distribution Panel, 1N-DL2 - Power Consumption (kWh)																													X																				X	X	
Lighting and Power Dist Panel, 1N-DH1 - Real Power (kW)																																							X										X	X	
Lighting and Power Dist Panel, 1N-DH1 - Power Consumption (kWh)																													X																				X	X	
CHILLED WATER SYSTEM																																																			
Main Distribution Pump, CHP-1 VFD - Start/Stop	X																																																		
Main Distribution Pump, CHP-1 VFD - Speed Setpoint						X																																													
Main Distribution Pump, CHP-1 VFD - Fault																												X																							X	
Main Distribution Pump, CHP-1 - Motor Run Status																													X									X													X	
Main Distribution Pump, CHP-1 - VFD Auto Status																														X																					X	

Affiliated Engineers

SYSTEM:

HVAC SYSTEMS

POINT DESCRIPTION	HARDWARE																											SOFTWARE																			
	OUTPUT (O)							INPUT (T, D, V, C)																				ALARMS									BAS FUNCTIONS												
	DIGITAL				ANALOG			DIGITAL										ANALOG										DIGITAL						ANALOG																
	Control Relay	Solenoid	Contactor (Start/Stop)	Floating Point (Triac)	Pneumatic Transducer	4-20mA, 2-10VDC, etc.	Electrical Transducer	Pressure Switch	Flow Switch	Temperature Switch	Humidity Switch	Switch Closure/Opening	Auxiliary Contact	Level Switch	Vibration Switch	Current Switch	Flow Totalizer (Pulse)	Temperature	Relative Humidity	PSIG, PSIA, PSID	Position	Flow	Level	Speed	Conductivity	KW	Misc	Equipment Fault	Equipment Status	Equipment HOA	Maintenance	Open/Closed	Critical	High Limit	High-High Limit	Low Limit	Low-Low Limit	Run Time Totalization	Scheduled Start/Stop	Totalization	Occupancy Reset	CO2 Reset	Day/Night Setback	Economizer	Temperature Control	Reheat Coil Reset	Hot Water OA Reset	Chilled Water Reset	Condenser Water Reset	Lead/Lag Control	LEED M&V	Integrated Communication	Comments
Main Distribution Pump, CHP-1 - Real Power (kW)																														X									X												X	X	
Main Distribution Pump, CHP-2 VFD - Start/Stop	X																																																			
Main Distribution Pump, CHP-2 VFD - Speed Setpoint						X																																														
Main Distribution Pump, CHP-2 VFD - Fault													X															X																							X	
Main Distribution Pump, CHP-2 - Motor Run Status																X													X								X														X	
Main Distribution Pump, CHP-2 - VFD Auto Status																														X																					X	
Main Distribution Pump, CHP-2 - Real Power (kW)																														X									X												X	X	
Building Entering Chilled Water Temperature																		X																X																X		
Building Leaving Chilled Water Temperature																		X																X																X		
Building Chilled Water Flow																						X																	X												X		
Distribution Supply Header Temperature																		X																X																X		
Distribution Supply Water Temperature Control Valve - Command						X																																														
Distribution Supply Header Flow																						X														X														X		
Distribution Differential Pressure																				X														X		X																
Distribution Bypass Flow Control Valve - Command						X																																														
Chilled Water Energy Usage - Current (BTU)																																							X											X		BTU to be calculated by EMCS
Chilled Water Energy Usage - Daily Total (BTU)																																							X													
Chilled Water Energy Usage - Monthly Total (BTU)																																							X													
Chilled Water Energy Usage - Yearly Total (BTU)																																							X													
CHILLED BEAM CHILLED WATER SYSTEM																																																				
Chilled Water Pump, CHP-3 VFD - Start/Stop	X																																																			
Chilled Water Pump, CHP-3 VFD - Speed Setpoint						X																																														
Chilled Water Pump, CHP-3 VFD - Fault																												X																							X	
Chilled Water Pump, CHP-3 - Motor Run Status																													X								X														X	
Chilled Water Pump, CHP-3 - VFD Auto Status																														X																					X	
Chilled Water Pump, CHP-3 - Real Power (kW)																														X									X												X	X	
Chilled Water Pump, CHP-4 VFD - Start/Stop	X																																																			
Chilled Water Pump, CHP-4 VFD - Speed Setpoint						X																																														
Chilled Water Pump, CHP-4 VFD - Fault													X															X																							X	
Chilled Water Pump, CHP-4 - Motor Run Status																X													X								X														X	
Chilled Water Pump, CHP-4 - VFD Auto Status																														X																					X	
Chilled Water Pump, CHP-4 - Real Power (kW)																														X									X												X	X	
Supply Water Temperature																		X																X		X																
Supply Water Temperature Control Valve - Command						X																																														
Return Water Temperature																		X																																		
Distribution Differential Pressure																				X														X		X																
Distribution Supply Header Flow																						X														X														X		
Distribution Bypass Flow Control Valve - Command						X																																														
HEATING HOT WATER SYSTEM																																																				
Main Distribution Pump, HWP-1 VFD - Start/Stop	X																																																			
Main Distribution Pump, HWP-1 VFD - Speed Setpoint						X																																														
Main Distribution Pump, HWP-1 VFD - Fault																												X																							X	
Main Distribution Pump, HWP-1 - Motor Run Status																													X								X														X	
Main Distribution Pump, HWP-1 - VFD Auto Status																														X																					X	
Main Distribution Pump, HWP-1 - Real Power (kW)																														X									X												X	X	
Main Distribution Pump, HWP-2 VFD - Start/Stop	X																																																			
Main Distribution Pump, HWP-2 VFD - Speed Setpoint						X																																														
Main Distribution Pump, HWP-2 VFD - Fault													X															X																							X	
Main Distribution Pump, HWP-2 - Motor Run Status																X													X								X														X	
Main Distribution Pump, HWP-2 - VFD Auto Status																														X																					X	

Affiliated Engineers

SYSTEM:

HVAC SYSTEMS

POINT DESCRIPTION	HARDWARE																											SOFTWARE																				
	OUTPUT (O)							INPUT (T, D, V, C)																				ALARMS										BAS FUNCTIONS												
	DIGITAL				ANALOG			DIGITAL										ANALOG										DIGITAL						ANALOG																	
	Control Relay	Solenoid	Contactor (Start/Stop)	Floating Point (Triac)	Pneumatic Transducer	4-20mA, 2-10VDC, etc.	Electrical Transducer	Pressure Switch	Flow Switch	Temperature Switch	Humidity Switch	Switch Closure/Opening	Auxiliary Contact	Level Switch	Vibration Switch	Current Switch	Flow Totalizer (Pulse)	Temperature	Relative Humidity	PSIG, PSIA, PSID	Position	Flow	Level	Speed	Conductivity	KW	Misc	Equipment Fault	Equipment Status	Equipment HOA	Maintenance	Open/Closed	Critical	High Limit	High-High Limit	Low Limit	Low-Low Limit	Run Time Totalization	Scheduled Start/Stop	Totalization	Occupancy Reset	CO2 Reset	Day/Night Setback	Economizer	Temperature Control	Reheat Coil Reset	Hot Water OA Reset	Chilled Water Reset	Condenser Water Reset	Lead/Lag Control	LEED M&V	Integrated Communication	Comments
Main Distribution Pump, HWP-2 - Real Power (kW)																														X										X											X	X	
Building Entering Hot Water Temperature																		X																X						X											X		
Building Leaving Hot Water Temperature																		X																X																	X		
Building Hot Water Flow																						X																		X											X		
Distribution Supply Header Temperature																		X																X																	X		
Distribution Supply Water Temperature Control Valve - Command						X																																														
Distribution Supply Header Flow																						X														X															X		
Distribution Differential Pressure																				X														X		X																	
Distribution Bypass Flow Control Valve - Command						X																																														
Hot Water Energy Usage - Current (BTU)																																								X											X		BTU to be calculated by EMCS
Hot Water Energy Usage - Daily Total (BTU)																																								X													
Hot Water Energy Usage - Monthly Total (BTU)																																								X													
Hot Water Energy Usage - Yearly Total (BTU)																																								X													
CHILLED BEAM HOT WATER SYSTEM																																																				
Hot Water Pump, HWP-5 VFD - Start/Stop	X																																																			
Hot Water Pump, HWP-5 VFD - Speed Setpoint						X																																														
Hot Water Pump, HWP-5 VFD - Fault																												X																								X	
Hot Water Pump, HWP-5 - Motor Run Status																													X									X														X	
Hot Water Pump, HWP-5 - VFD Auto Status																														X																						X	
Hot Water Pump, HWP-5 - Real Power (kW)																														X										X											X	X	
Hot Water Pump, HWP-6 VFD - Start/Stop	X																																																			
Hot Water Pump, HWP-6 VFD - Speed Setpoint						X																																														
Hot Water Pump, HWP-6 VFD - Fault													X															X																								X	
Hot Water Pump, HWP-6 - Motor Run Status																X													X									X														X	
Hot Water Pump, HWP-6 - VFD Auto Status																														X																						X	
Hot Water Pump, HWP-6 - Real Power (kW)																														X										X											X	X	
Supply Water Temperature																		X																X		X																	
Supply Water Temperature Control Valve - Command						X																																														
Return Water Temperature																		X																																			
Distribution Differential Pressure																				X														X		X																	
Distribution Supply Header Flow																						X														X															X		
Distribution Bypass Flow Control Valve - Command						X																																														
MAGNET WATER HEAT RECOVERY SYSTEM																																																				
Hot Water Pump, HWP-3 VFD - Start/Stop	X																																																			
Hot Water Pump, HWP-3 VFD - Speed Setpoint						X																																														
Hot Water Pump, HWP-3 VFD - Fault																												X																								X	
Hot Water Pump, HWP-3 - Motor Run Status																													X									X														X	
Hot Water Pump, HWP-3 - VFD Auto Status																														X																						X	
Hot Water Pump, HWP-3 - Real Power (kW)																														X										X											X	X	
Hot Water Pump, HWP-4 VFD - Start/Stop	X																																																			
Hot Water Pump, HWP-4 VFD - Speed Setpoint						X																																														
Hot Water Pump, HWP-4 VFD - Fault													X															X																								X	
Hot Water Pump, HWP-4 - Motor Run Status																X													X									X														X	
Hot Water Pump, HWP-4 - VFD Auto Status																														X																						X	
Hot Water Pump, HWP-4 - Real Power (kW)																														X										X											X	X	
Heat Exchanger, HX-1, Isolation Valve - Command	X																																																			
Heat Exchanger, HX-1, Isolation Valve - Open Indication												X																			X																						
Heat Exchanger, HX-1, Bypass Valve - Command	X																																																			
Heat Exchanger, HX-1, Bypass Valve - Open Indication												X																			X																						
Heat Exchanger, HX-1, Temperature Control Valve - Command						X																																														
Heat Exchanger, HX-2, Isolation Valve - Command	X																																																			

Affiliated Engineers

SYSTEM:

HVAC SYSTEMS

POINT DESCRIPTION	HARDWARE																											SOFTWARE																				
	OUTPUT (O)							INPUT (T, D, V, C)																				ALARMS									BAS FUNCTIONS													
	DIGITAL				ANALOG			DIGITAL										ANALOG										DIGITAL						ANALOG																	
	Control Relay	Solenoid	Contactor (Start/Stop)	Floating Point (Triac)	Pneumatic Transducer	4-20mA, 2-10VDC, etc.	Electrical Transducer	Pressure Switch	Flow Switch	Temperature Switch	Humidity Switch	Switch Closure/Opening	Auxiliary Contact	Level Switch	Vibration Switch	Current Switch	Flow Totalizer (Pulse)	Temperature	Relative Humidity	PSIG, PSIA, PSID	Position	Flow	Level	Speed	Conductivity	KW	Misc	Equipment Fault	Equipment Status	Equipment HOA	Maintenance	Open/Closed	Critical	High Limit	High-High Limit	Low Limit	Low-Low Limit	Run Time Totalization	Scheduled Start/Stop	Totalization	Occupancy Reset	CO2 Reset	Day/Night Setback	Economizer	Temperature Control	Reheat Coil Reset	Hot Water OA Reset	Chilled Water Reset	Condenser Water Reset	Lead/Lag Control	LEED M&V	Integrated Communication	Comments
Heat Exchanger, HX-2, Isolation Valve - Open Indication												X																				X																				
Heat Exchanger, HX-2, Temperature Control Valve - Command						X																																													
Heat Exchanger, HX-3, Isolation Valve - Command	X																																																		
Heat Exchanger, HX-3, Isolation Valve - Open Indication												X																				X																				
Heat Exchanger, HX-3, Temperature Control Valve - Command						X																																													
Preheat Hot Water Supply Temperature																		X																X		X																
Preheat Hot Water Return Temperature																		X																																	
Expansion Tank (System) Pressure																				X																X																
Preheat Hot Water Distribution Differential Pressure																				X														X		X																
Distribution Supply Header Flow																						X														X														X		
Distribution Bypass Flow Control Valve - Command						X																																													
Magnet Cooling Water Pump, MCP-1 VFD - Start/Stop	X																																																		
Magnet Cooling Water Pump, MCP-1 VFD - Speed Setpoint						X																																													
Magnet Cooling Water Pump, MCP-1 VFD - Fault													X															X																							X	
Magnet Cooling Water Pump, MCP-1 - Motor Run Status																X													X								X														X	
Magnet Cooling Water Pump, MCP-1 - VFD Auto Status																														X																				X	
Magnet Cooling Water Pump, MCP-1 - Real Power (kW)																														X									X										X	X	
Heat Exchanger, HX-1, Isolation Valve - Command	X																																																		
Heat Exchanger, HX-1, Isolation Valve - Open Indication												X																				X																				
Magnet Cooling Water Supply Temperature																		X																X		X																
Magnet Cooling Water Return Temperature																		X																X		X																
Magnet Cooling Water Flow																						X																	X											X		
Magnet Cooling Water Energy Usage - Current (BTU)																																							X										X		BTU to be calculated by EMCS
Magnet Cooling Water Energy Usage - Daily Total (BTU)																																							X												
Magnet Cooling Water Energy Usage - Monthly Total (BTU)																																							X												
Magnet Cooling Water Energy Usage - Yearly Total (BTU)																																							X												
AIR HANDLING UNITS - (TYP. FOR AHU-1 AND AHU-2)																																																			
Fire Alarm Shutdown													X																			X																				
Exhaust Air Inlet - Humidity																			X															X																		
Exhaust Air Inlet Static Pressure Switch - Low								X																								X																				
Exhaust Air Filter - High Pressure Switch								X																						X																						
Exhaust Outlet Isolation Damper - Command						X																																													
Exhaust Outlet Isolation Damper - Open Indication													X																			X																				
Exhaust Outlet Isolation Damper - Closed Indication													X																			X																				
HRW Exhaust Air Bypass Damper - Command	X																																																		
HRW Exhaust Air Bypas Damper - Open Indication													X																			X																				
HRW Exhaust Air Bypas Damper - Closed Indication													X																			X																				
Exhaust Air Fan Array VFD - Start/Stop	X																																																		
Exhaust Air Fan Array VFD - Speed Setpoint						X																																													
Exhaust Air Fan Array VFD - Fault													X															X																							X	
Exhaust Air Fan Array VFD - Auto Status																														X																				X	
Exhaust Air Fan Array VFD - Real Power (kW)																														X									X										X	X	
Exhaust Air Fan Backdraft Damper Position - Run Status (4 each)													X																X								X														X	
Supply Air Fan Array VFD - Start/Stop	X																																																		
Supply Air Fan Array VFD - Speed Setpoint						X																																													
Supply Air Fan Array VFD - Fault													X															X																							X	
Supply Air Fan Array VFD - Auto Status																														X																				X	
Supply Air Fan Array VFD - Real Power (kW)																														X									X										X	X	
Supply Air Fan Backdraft Damper Position - Run Status (4 each)													X																X								X														X	
Outside Air Isolation Damper - Command	X																																																		
Outside Air Isolation Damper - Open Indication													X																			X																				
Outside Air Isolation Damper - Closed Indication													X																			X																				

Affiliated Engineers

SYSTEM:

HVAC SYSTEMS

	HARDWARE																											SOFTWARE																					
	OUTPUT (O)							INPUT (T, D, V, C)																				ALARMS									BAS FUNCTIONS													
	DIGITAL				ANALOG			DIGITAL										ANALOG										DIGITAL						ANALOG																	
POINT DESCRIPTION	Control Relay	Solenoid	Contactor (Start/Stop)	Floating Point (Triac)	Pneumatic Transducer	4-20mA, 2-10VDC, etc.	Electrical Transducer	Pressure Switch	Flow Switch	Temperature Switch	Humidity Switch	Switch Closure/Opening	Auxiliary Contact	Level Switch	Vibration Switch	Current Switch	Flow Totalizer (Pulse)	Temperature	Relative Humidity	PSIG, PSIA, PSID	Position	Flow	Level	Speed	Conductivity	KW	Misc	Equipment Fault	Equipment Status	Equipment HOA	Maintenance	Open/Closed	Critical	High Limit	High-High Limit	Low Limit	Low-Low Limit	Run Time Totalization	Scheduled Start/Stop	Totalization	Occupancy Reset	CO2 Reset	Day/Night Setback	Economizer	Temperature Control	Reheat Coil Reset	Hot Water OA Reset	Chilled Water Reset	Condenser Water Reset	Lead/Lag Control	LEED M&V	Integrated Communication	Comments
Outside Air Prefilter - High Pressure Switch								X																							X																					
Outside Air Final Filter - High Pressure Switch								X																							X																					
HRW Supply Air Bypass Damper - Command	X																																																		
HRW Supply Air Bypas Damper - Open Indication													X																			X																				
HRW Supply Air Bypas Damper - Closed Indication													X																			X																				
Freezestat										X																					X		X																			
Heat Recovery Coil Temperature Control Valve - Command						X																																													
Heat Recovery Leaving Air Temperature																		X																X		X														X		
Humidifier "A" - Enable	X																																																		
Humidifier "A" - Fault												X																X																								
Humidifier "A" - Control						X																																													
Humidifier "B" - Enable	X																																																		
Humidifier "B" - Fault												X																X																								
Humidifier "B" - Control						X																																													
Cooling Coil Temperature Control Valve - Command						X																																													
Supply Air - Flow																						X												X		X														X		
Supply Air - Humidity																			X															X																X		
Supply Air - Temperature																		X																X		X														X		
Supply Air - Pressure																				X														X		X																Common to both units
Supply Air Fan Suction Pressure Switch - Low								X																									X																			
Supply Air Static Pressure Switch - High								X																									X																			
Supply Air Smoke/Isolation Damper - Command						X																																													
Supply Air Smoke/Isolation Damper - Open Indication													X																			X																				
Supply Air Smoke/Isolation Damper - Closed Indication													X																			X																				
Supply Air Smoke/Isolation Damper - Differential Pressure																				X																															
Heat Recovery Wheel (HRW) - Enable	X																																																		
Heat Recovery Wheel (HRW) General Fault Alarm																																																		X	
Heat Recovery Wheel (HRW) VFD Fault Alarm																																																		X	
Heat Recovery Wheel (HRW) Rotation Alarm																																																		X	
Heat Recovery Wheel (HRW) Exhaust Air Inlet Temperature																																																	X	X	
Heat Recovery Wheel (HRW) Exhaust Air Outlet Humidity																																																	X	X	
Heat Recovery Wheel (HRW) Exhaust Air Outlet Temperature																																				X													X	X	
Heat Recovery Wheel (HRW) Supply Air Temperature																																																	X	X	
Heat Recovery Wheel (HRW) Outside Air Temperature																																																	X	X	
Supply Air Distribution - Pressure																				X														X		X																Common to both units
Exhaust Air Distribution - Pressure																				X														X		X																Common to both units
FAN COIL UNITS - Cooling Only (typical)																																																			
Unit Start/Stop	X																																																		
Unit Run Status																X													X								X															
Cooling Coil Valve						X																																													
Space Temperature																		X																X		X																
Cooling Coil Pan Moisture Detection														X																			X																			
FAN COIL UNITS - Heating & Cooling (typical)																																																			
Unit Start/Stop	X																																																		
Unit Run Status																X													X								X															
Cooling Coil Valve						X																																													
Heating Coil Valve						X																																													
Space Temperature																		X																X		X																
Cooling Coil Pan Moisture Detection														X																			X																			
R.I. FUME HOOD EXHAUST																																																			
Exhaust Fan, EF-5, VFD - Start/Stop	X																																																		
Exhaust Fan, EF-5, VFD - Speed Setpoint						X																																													

Affiliated Engineers

SYSTEM:

HVAC SYSTEMS

| POINT DESCRIPTION | HARDWARE | | | | | | | | | | | | | | | | | | | | | | | | | | | SOFTWARE | | | | | | | | | | | | | | | | | | |

Affiliated Engineers

SYSTEM:

HVAC SYSTEMS

| POINT DESCRIPTION | HARDWARE | | | | | | | | | | | | | | | | | | | | | | | | | | SOFTWARE | | | | | | | | | | | | | | | | | | |

Affiliated Engineers

SYSTEM:

HVAC SYSTEMS

| | HARDWARE | | |

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SECTION 23 09 23

DIRECT DIGITAL CONTROLLERS AND NETWORKS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0901 - Control Systems Integration

B. Section 23 09 03 - Control Instrumentation

C. Section 23 09 24 - Graphical User Interface Integration

D. Section 23 09 93 - Control Sequences

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 DEFINITIONS

A. The following abbreviations, acronyms, and definitions may be used in addition to those found elsewhere in Contract Documents.

1. ASC: Application Specific Controller. A networked device or node that contains a complete, configurable application that is specific to a particular task.
2. Alarms & Events: The exchange of data between devices related to the occurrence of a predefined condition that meets specific criteria (event).
3. BC: Building Controller. Provide supervisory control, scheduling, trend logging & alarm handling.
4. B-OWS: BACnet Operator Workstation
5. B-BC: BACnet Building Controller. Same as SLC.
6. B-AAC: BACnet Advanced Application Controller. Same as PPC.
7. B-ASC: BACnet Application Specific Controller
8. B-SA: BACnet Smart Actuator
9. B-SS: BACnet Smart Sensor
10. BBMD: BACnet Broadcast Management Device
11. BIBBS: BACnet Interoperability Building Blocks. Specific individual function blocks for data exchange between interoperable devices.
12. Broadcasting: The propagation of data from a device to the control network. Software objects that broadcast data to the network may include the following parameters:
13. Send on Delta: An adjustable parameter that defines a requirement to broadcast when the data generated by the software object changes by an amount that exceeds this parameter's value. For binary data, this parameter defaults to a change of state. The broadcast of data is initiated when this criteria and the minimum send time requirement have been met. Also referred to as a "Change of Value".

14. Minimum Send Time: An adjustable parameter that defines a mandatory time period during which no broadcasting of data will occur. Once this time period has been exceeded without a broadcast, the send on delta parameter or the maximum send time parameter shall determine when a broadcast is initiated.
15. Maximum Send Time: An adjustable parameter that defines the maximum time period between broadcasts of a software object's data to the network. Should the value of a software object remain constant over an extended period of time, the value will be rebroadcast once every maximum time period.
16. BTL: BACnet Testing Laboratory.
17. Channel: One or more segments not containing a router.
18. Domain: A logical collection of devices on one or more channels.
19. FLN: Floor Level Network. BACnet MS/TP (76.8kbs).
20. HMI: Human-Machine Interface. Graphical operator BAS interface. Same as Graphical User Interface (GUI).
21. LAN: Local Area Network. Same as Floor Level Network.
22. Maximum Send Time: Event driven communication parameter specifying the time period for which data must not be sent more than once.
23. Minimum Send Time: Event driven communication parameter specifying the time period for which data must be sent at least once.
24. PICS: Protocol Implementation Conformance Statement. Detailed description for a given BACnet device stating its inherent BACnet capabilities.
25. Point: Group of data, which corresponds to a hardware input, output, or calculated value.
26. PPC: Programmable Process Controller. Same as Advanced Application Controller (AAC)
27. Scheduling: The exchange of data between devices related to the establishment and maintenance of dates and times at which specified output actions are to be taken.
28. Send on Delta: Event driven communication parameter specifying the amount of variable change before data is to be sent between the Minimum and Maximum send times.
29. SLC: Supervisory Level Controller. Same as Building Controller.
30. Segment: A section of uninterrupted cable where multiple devices may be installed.
31. Subnet: Logical division of a domain.
32. Trending: The accumulation of (time, value) pairs at specified rates for a specified period duration.

1.4 SUBMITTALS

A. Shop Drawings: Refer to Section 23 0901 - Control Systems Integration.

B. Operating and Maintenance Manuals: Refer to Section 23 0901 - Control Systems Integration.

C. Software Manual:

1. As part of operating and maintenance manuals, submit one software manual per workstation plus one extra copy for archive use. Software manuals shall be divided into separate parts with tabs for each part.
2. Software manual parts shall include:
   a. Complete description of operating system including all commands, configuration programs, printouts, logs, database functions and passwords. Describe general operating procedures, starting with system overview and proceeding to detailed description of each software command feature with sample printed displays and system function description for each option. Include instructions on verifying errors, status, changing passwords and initiating or disabling control programs.
   b. Complete description of programming language including all commands, configuration programs, control loop functions and testing. Describe general programming procedures, starting with system overview and proceeding to detailed description of each software command feature. Include

instructions on creating or modifying any control algorithm or parameter, debugging, etc. This shall include all control functions, algorithms, mathematic equations, variables, setpoints, time periods, messages, and other information necessary to load, alter, test and execute custom or pre-written programs.

c. Software Backup: Upon successful completion of acceptance testing, submit to Laboratory 2 archive copies of all accepted versions of source code and compiled code for all application programs and data files on CD ROM backup disks. All control software must be readily accessible by Laboratory using BAS workstation hardware and software.

1.5 FCC COMPLIANCE

A. Digital equipment furnished under this contract shall be tested and made to comply with limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environments. Literature shall so note and equipment shall be so labeled to show this compliance.

PART 2 - PRODUCTS

2.1 DIRECT DIGITAL CONTROL (DDC) CONTROLLERS

A. General:

1. DDC shall be microprocessor based, field programmable controllers, capable of performing control and energy management functions, and shall be UL listed as Signaling Systems. Each controller shall include its own microprocessor, power supply, input/output modules, and termination modules as required to perform intended function.
2. DDC shall receive discrete electrical and/or analog electronic field input signals, convert signals for use by controller, perform control sequences, convert controller information into output signals, and provide control output signals to actuators and field control devices. Inputs and outputs, including communication connections, shall be electrically or optically isolated from controllers.
3. DDC with analog input modules shall be capable of accepting any form of linear or non-linear voltage (0-5 VDC or 0-10 VDC), current (4-20 mA) or resistive input (0-1000 ohm or thermistor).
4. DDC with discrete input modules shall be capable of accepting discrete inputs from any device with isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (NC) configuration. Provide visible status lights (LEDs) to indicate input point status.
5. Provide input modules capable of interfacing with pulsed output type sensors as required.
6. DDC with discrete output modules shall have isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (NC) configuration. Provide visible status lights (LEDs) to indicate output point status.
7. DDC shall have capability to scale, offset, and display proper analog value without field hardware modification. DDC shall convert analog input signals to digital values (A/D conversion) and convert digital values to analog outputs (D/A conversion) for modulating control purposes.
8. Failsafe hardware shall be provided such that BAS failures result in immediate return to local control. If DDC uses database values from other DDCs and communication network fails or malfunctions, control loop outputs shall continue to function using last value received from BAS.
9. Failure of network or control devices (i.e. building level controllers, floor level controllers, application specific controllers, routers, repeaters, etc.) shall be alarmed at the Operator Workstation as a Level 3 Critical Alarm.
10. All DDC Hardware shall meet the following requirements:
    a. All DDC shall be connected to an ASHRAE 135 MS/TP, BACnet/ARCNET, or BACnet/IP control network and communicate via ASHRAE 135 exclusively.
    b. MS/TP controllers shall operate with a baud rate of 38.4 kbps minimum.

c. All DDC shall implement all required functionality of the application network interface via BACnet objects, properties, and services.

d. All DDC shall conform to the BACnet Testing Lab's Device Implementation Guidelines and be BTL Listed.

e. Application programs and configuration settings shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration settings. Batteries shall maintain volatile memory and real time clocks for period of at least 72 hours during power failure. Batteries shall be maintenance free and have minimum life of 2 years. Provide system annunciation of low battery power for each battery.

f. All settings and parameters used by the application shall be fully configurable to the greatest extent possible, via properties of BACnet objects that can be written to via BACnet services or via properties of BACnet objects that can be written to via BACnet services for the following:

1). Setpoint

2). Alarm limit

3). Schedule modification

4). Trend modification

g. All other settings and parameters that cannot be written to via BACnet services shall be fully configurable via either properties of BACnet objects that can be written to with a configuration tool, or via hardware settings on the controller itself to support the application.

11. Each DDC panel shall have sufficient I/O capacity to perform specified control sequences and/or include points listed in point schedules. If DDC does not have sufficient capacity, provide additional slave panels to achieve required point count.

12. Analog and critical safety discrete control loops shall have inputs and outputs into/from same DDC panel. Analog control loops for major equipment (chilled water, hot water, convertors, air handling units, etc.) shall have PID control.

B. BACnet Building Controller (B-BC):

1. BACnet Building Controllers (B-BCs) shall provide direct connection to high speed, BACnet/IP Local Area Network (LAN) and Campus Ethernet network and serve as communications router for other controllers on slower speed BACnet MS/TP or BACnet/ARCNET Floor Level Network (FLN).

2. B-BC's shall have sufficient processor capabilities, hard-drive storage and RAM to implement all types of custom software applications and shall provide supervisory control, scheduling, trend logging & alarm handling functions as follows:

a. Scheduling:

1). Each B-BC shall support a minimum of 250 BACnet Schedule Objects and 250 BACnet Calendar Objects.

b. Trending:

1). Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.

2). B-BC shall periodically upload trended data to networked BAS Web Application Server for long term archiving.

3). Archived data shall be stored in standard database format and shall be made available for use in third-party spreadsheet or database programs.

c. Alarm Generation:

1). Alarms may be generated within the system for any object change of value or state either real or calculated. This includes analog object value changes, binary object state changes, and various controller communication failures.

2). B-BC shall periodically upload alarm logs to networked BAS Web Application Server for long term archiving (minimum of one year retention of alarm logs).

3. B-BCs shall have uninterrupted real time clocks capable of time of day, week, and year information to system as needed to perform software functions. Clock shall be programmed to reset twice per year to allow for Daylight Savings Time. Clocks in multiple DDC panels shall be synchronized to automatically match designated B-BC or Web Server. Accuracy shall be within 1 second per day.
4. Batteries shall maintain volatile memory and real time clocks for period of at least 72 hours during power failure. Batteries shall be maintenance free and have minimum life of 2 years. When power has been restored, the following shall occur automatically:
   a. Orderly startup of controlled equipment (user defined)
   b. Continuation of control algorithms
   c. Database revision
   d. Logging of power interruption and restoration times
   e. Battery recharging
5. Provide local visual indication and system annunciation of low battery power for each battery.
6. Each B-BC shall include its own micro-processor, power supply, input/output modules, and termination modules as required to perform intended function.
7. BACnet UDP port number to always be set to 47808 (BAC0).

C. BACnet Advanced Application Controllers (B-AAC):
1. B-AACs are defined as having sufficient processor capabilities and RAM to implement all types of custom software applications.
2. B-AACs shall be capable of communicating to BAS network via FLN connected to Building Controller.
3. Provide at least one extra communication port at each B-AAC for direct connecting a notebook computer or hand-held terminal.

D. BACnet Application Specific Controllers (B-ASC):
1. B-ASCs are defined as having standard software burned into EPROM, set points in EEPROM or RAM maintained by battery, and are designed to handle specific types of control sequences.
2. B-ASCs shall be capable of communicating to BAS network via FLN connected to Building Controller.
3. Provide communication ports at room temperature sensors/thermostats for interface with local terminal equipment controllers. Communication port shall be integral to room temperature sensor/thermostat or mounted directly adjacent to sensor.
4. Air terminal (VAV box) controllers with integrated damper actuator shall provide analog control of damper actuator. Floating point (triac) damper control will only be allowed if analog damper position feedback is provided.

E. BACnet Router
1. BACnet MS/TP to BACnet/IP and BACnet/ARCNET to BACnet/IP Routers shall perform layer 3 routing of BACnet MS/TP or BACnet/ARCNET packets over an IP network in accordance with ASHRAE 135 Annex J. The router shall provide the appropriate connection to the IP network and connections to the BACnet MS/TP or BACnet/ARCNET network. BACnet Routers shall be capable of configuration via DHCP and Write-Broadcast-Distribution-Table messages but shall not rely on these services for configuration.
2. One router in the IP subnetwork shall be designated as the BBMD (BACnet Broadcast Management Device) and shall be indicated as so on the Network Architecture.
3. BACnet router functionality can also be incorporated into BACnet Building Controllers.

F. BACnet Gateways:
1. Provide gateways to connect BACnet to non-BACnet devices, and non-BACnet DDC controlled equipment.

2. Provide with each gateway an interoperability schedule, showing each point or event on the non-BACnet side that the BACnet "client" will read, and each parameter that the BACnet network will write to. Describe this interoperability in terms of BACnet services, or Interoperability Building Blocks (BIBBS), defined in ASHRAE 135 Annex K. Provide two-year minimum warranty for each gateway, including parts and labor.
3. The following minimum capabilities are required:
   a. Gateways shall be able to read and view all readable object properties listed in the interoperability schedule on the non-BACnet network to the BACnet network and vice versa where applicable.
   b. Gateways shall be able to write to all writeable object properties listed in the interoperability schedule on the non-BACnet network from the BACnet network and vice versa where applicable.
   c. Gateways shall provide single-pass (only one protocol to BACnet without intermediary protocols) translation from the non-BACnet protocol to BACnet and vice versa.
   d. Gateways shall meet the requirements of Data Sharing Read Property (DS-RP-B), Data Sharing Write Property (DS-WP-B), Device Management Dynamic Device Binding-B (DM-DDB-B), and Device Management Communication Control (DM-DCC-B) BIBBs, in accordance with ASHRAE 135.
   e. Gateways shall include all hardware, software, software licenses, and configuration tools for operator-to-gateway communications. Provide backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

G. Power Supplies:
1. Power supplies shall operate on nominal 120 V, 60 Hz, single-phase power. DDC Controllers shall be provided with surge and noise protection. Power fluctuation shall not affect control system. Include surge protection on telephone line.
   a. Isolation transformers shall be included when connections are being made between 2 separate buildings.

2.2 DIRECT DIGITAL CONTROL SOFTWARE

A. General:
1. DDC control strategies shall be Laboratory definable from operator terminals or workstations.
2. Software functions and algorithms shall be sufficient to enable implementation of control sequences as specified and shall be able to maintain continuous control as intended.
3. Control functions shall include both mathematical and logical operators. Control algorithms shall include proportional, integral and derivative control (PID). Adaptive (self-tuning) PID loop parameters, if offered by DDC manufacturer, shall not be used unless adaptive limits are used to adjust limit values based on system status; or written request is submitted and approved by Engineer.
4. Allow operators to assign unique identifiers of their choice to each connected point. Identifiers shall have at least 8 alpha/numeric characters. References to these points in programs, reports and command messages shall be by these identifiers.
5. Provide access control (user defined passwords) for system operation. There shall be minimum of 3 access levels. First level shall allow system monitoring only. Second level shall allow monitoring, set point adjustment, and scheduling revision. Third level shall allow modification of control algorithms. System shall return to secured (monitoring only) mode after 5 minutes of inactive operation.
6. Each DDC shall contain self-diagnostics that continuously monitor proper operation of panel.
7. If microprocessor malfunctions, control loop outputs shall continue to function using last value received from microprocessor.

B. Building/Floor Level DDC Software:
1. Provide DDC software application program modules for performing energy management control functions such as time of day change of database values (programmed start/stop, temperature setbacks,

etc.), supply air temperature reset based on space load demand, economizer control, optimum start/stop based on current indoor and outdoor psychrometrics, duty cycling and Laboratory tailored programs required for special applications such as VAV fan matching and supply fan control, enthalpy control, intermediate season or "dead band" control, totalizing, and holiday programming.

2. Provide manufacturer's standard operating system for real time control of system interactions, including database information requests/transfers by system hardware or by operators. Operating system shall also have the following additional capabilities (given that operator has appropriate security access level):
   a. User interface and online system configuration software embedded in Building Controller.
   b. Support for Web services at the automation network level.
   c. Displaying database (point) value including measured values, controlled variables, setpoints, gain factors, and any other adjustable parameters.
   d. Changing or overriding any database value.
   e. Error detection, correction, re-transmission of database values, arithmetic or logical faults.
   f. Alarm reporting including sending alarms to remote workstations on network or by modem.
   g. Alarm buffer to retain alarms in order of importance without losing any alarms.
   h. Creating and displaying historical trend logging of any value, limited only by available memory.
   i. Creating new variable database values (soft points) based on arithmetic calculation (including summation or totalizing) on other database values.
   j. Adding new hardware points without overall BAS shutdown.

C. BACnet Application Specific Controller Software:
   1. Manufacturer's standard software for B-ASC’s may be used only if control sequences can be implemented without modification. If control sequence cannot be accomplished with standard software, provide battery backed RAM or EEPROM DDC capable of being programmed for specified control sequence.
   2. Provide software for hand-held keyboard and display units or portable PC units to communicate with terminal controllers at room level network. Software shall allow access to modify, delete or create control strategies at room sensor location.

D. BACnet Advanced Application Controller Software:
   1. Manufacturer's standard software shall be used to create custom control strategies within advanced application controllers as specified in control sequences. Program shall be configurable from Engineering workstation software.

2.3 DDC ENGINEERING (PROGRAMMING) SOFTWARE

A. Provide engineering software to be installed on (1) Engineering Workstation to be provided by controls provider.

B. User Programmability:
   1. Controller Programming:
      a. Engineering workstation software shall include field-engineering tools for programming all controllers supplied.
      b. All application software shall be interactive, fully prompted, menu driven and shall provide the following functionality as a minimum:
         1). Determine control strategies, which have been defined for specific piece of equipment.
         2). Add control loops to system using English language type program language equal to BASIC or other easily learned language. (PASCAL, C, or other assembly type languages are not acceptable.)
         3). Add points to system.

4). Create, modify or delete control strategies.
5). Create, modify or delete system graphics.
6). Assign sensors and/or actuators to control strategy.
7). Tune control loops through adjustment of control loop parameters.
8). Enable or disable control strategies.
9). Generate hard copy records of control strategies on printer.
10). Select points to be alarmable and define alarm state(s).
11). Select points to be trended over period of time and initiate recording of values.
12). Override Input/Output points for each individual controller.

2.4 ENGINEERING WORKSTATION

A. Provide one desktop engineering workstation to be located in mechanical penthouse.

B. Laminated plastic nameplate shall be provided for workstation. Nameplate shall identify the function, network address and identifier of the workstation. Laminated plastic shall be 0.125 inch thick, white with black center core. Nameplate shall be a minimum of 1 by 3 inches with minimum 0.25 inch high engraved block lettering. Nameplate shall be attached to the device in conspicuous location.

C. Engineering Workstation Hardware (workstation) shall be a standard unmodified digital desktop computer of modular design. The modular components of the desktop shall be products of a single manufacturer which advertises service in all 48 contiguous states.

D. Workstation shall meet the following minimum requirements:
1. Case and 250 watt power supply.
2. Processor speed: 150% the stated requirements of the software to be installed on the workstation.
3. BIOS in Flash Memory.
4. Sufficient expansion slots to be properly configured for its intended use.
5. Random Access Memory (RAM): 150% the stated requirements of the software to be installed on the workstation.
6. Video Output Card: Supports at least 32 bit color at a minimum resolution of 1280 by 1024 at a minimum refresh rate of 70 Hz.
7. 101 key, keyboard with 12 function keys.
8. Monitor: 21-inch LCD monitor with a minimum resolution of 1024 by 768 pixels, non-interlaced, a maximum dot pitch of 0.28 millimeters, and a minimum refresh rate of 70Hz. Provide two monitors for Central Utility Plant workstation.
9. Communication Ports: serial port, one enhanced parallel port and two USB ports in addition to any ports required for the keyboard and mouse.
10. CD-RW/DVD ROM 24X Drive
11. Hard Drive: 500 GB formatted disk space with an average seek time of 7 milliseconds or less.
12. Network interface card: Integrated Gigabit Ethernet NIC with an RJ45 connector and associated hardware.
13. All required cables for connecting to network and other remote devices.
14. Mouse with mouse pad.
15. UPS with 30 minute backup battery.
16. Software;
    a. The operating system (OS) shall fully support all installed software and peripherals and shall be able to obtain screen capture of the monitor display being viewed.

b. Virus Protection Software shall consist of the project site's standard virus protection software complete with a virus definition update subscription.

c. Latest version of Microsoft Office Professional

d. Latest version of Adobe Acrobat.

2.5 OPERATOR WORKSTATION

A. Operator Workstation shall communicate with BAS Web Server via standard web interface software. Operator Workstations for operator interface to BAS for monitoring, control, and database management shall be provided by Laboratory. Proprietary software shall not be required for proper monitoring and control of HVAC systems as specified in section 23 0924 - Graphical User Interface Integration.

2.6 WEB APPLICATION SERVER

A. Web Application Server is an existing Johnson Controls Extended Architecture Web Server. Refer to 23 09 24 - Graphical User Interface Integration for additional requirements.

2.7 NETWORK HARDWARE

A. Provide network interface hardware for each device connected to network. Each device shall have sufficient performance as not to degrade specified processing speed.

B. Provide network cabling with sufficient performance as not to degrade specified communication speed. Cabling shall be compatible with proposed system and shall comply with requirements specified in Section 23 0901 - Control Systems Integration.

C. Provide other network support devices that are required for proper operation of network, such as file servers, signal repeaters, network switches, routers, etc.

D. Provide network diagnostic tool for measuring/confirming bandwidth usage on IP layer.

PART 3 - EXECUTION

3.1 GENERAL

A. Install control equipment in neat, professional manner to satisfaction of Architect and Engineer.

B. Coordinate timely delivery of materials and supervise installation of DDC and network cabling and devices.

C. Install DDC and network control devices in accessible locations.

3.2 OVERALL BAS ARCHITECTURE

A. Provide hardware/software to update controller database in less than 1 second for fast-acting control loops such as pressure control, air or water flow rate control, and air handling unit temperature control, or 10 seconds or less for other control loops.

B. Control software algorithm and inputs and outputs for a single system or piece of equipment shall reside on a single controller and shall not be distributed amongst multiple controllers. If multiple pieces of equipment are to be interlocked, a single “Master” controller shall provide control for all interlocked pieces of equipment, i.e. an AHU and interlocked return fan and exhaust fans.

C. Control loop software algorithm for each analog control loop shall reside on same controller as inputs and outputs required for that specific control loop.

D. Floor Level Network shall be multi-drop digital transmission network utilizing BACnet MS/TP communication.

E. Each multi-drop trunk shall be within manufacturer's allowable line lengths without signal degradation. Multi-drop trunks shall be interfaced to system via standard EIA or other industry recognized interfaces so that single failure does not disrupt or halt network.

F. Provide levels of connected networks to connect all DDC, including terminal DDC. Communications to terminal devices shall be similar to capabilities and functions of other DDC and shall be transparent to operator.

G. Alarm reports from DDC shall not be impeded by use of either remote or local monitor, or control stations on network either in access mode or programming mode

3.3 DIRECT DIGITAL CONTROLLERS

A. DDC Controller Usage:
   1. Each DDC shall have sufficient I/O capacity to perform specified control sequences and/or include points listed in any point schedules. If DDC does not have sufficient capacity, provide additional slave panels to achieve required point count.
   2. Analog and critical safety discrete control loops shall have inputs and outputs into/from same DDC . Analog control loops for major equipment (chilled water, hot water, convertors, air handling units, etc.) shall have PID control.

B. Point Capacity:
   1. Provide point capacity required plus spare I/O point capacity in each mechanical equipment room. Spare I/O point capacity is defined as terminal connections, which are ready to accept digital or analog inputs, dry contacts for digital outputs, and variable voltage or current terminals for analog outputs. Universal type points are acceptable for both discrete and analog type points. Spare points do not include any input or output conversion devices.
   2. Spare points in each mechanical room shall be as follows:
      a. 4 Digital Inputs
      b. 4 Digital Outputs
      c. 8 Analog Inputs
      d. 4 Analog Outputs

C. Building Controllers:
   1. Provide one BBMD in each IP subnet.
   2. BACnet UDP port number to always be set to 47808 (BAC0).

D. Gateways:
   1. Gateways may be used for communication with non-BACnet control hardware subject to all of the following limitations:
      a. Non-BACnet control hardware shall not be used for controlling built-up units.
      b. Non-BACnet control hardware shall not perform system scheduling functions.

E. Cabinets:
   1. Provide local control cabinets for DDCs.
   2. All control cabinets shall be labeled. Labels shall be keyed to the unique identifiers shown on the As-Built drawings.

F. Provide latest version of controller firmware. Include firmware updates for period after system acceptance, coinciding with warranty period. If the upgrade of firmware causes the need to upgrade or reconfigure/reprogram related systems, controllers or software, control contractor shall notify Laboratory prior to upgrade and provide additional work scope in coordination with other contractors, as required, at no cost to Laboratory.

3.4 ENGINEERING SOFTWARE

A. Engineering software shall be installed on BAS Web Application Server – refer to 23 09 24.

B. Security access levels for the engineering software shall be setup as follows:
   1. Guest (View-only) access level shall have the ability to perform the following tasks:
      a. View Data
      b. View Trends
   2. Operator access level shall have the ability to perform the following tasks:
      a. View Data.
      b. Acknowledge Alarms
      c. View Reports
      d. Override Points
      e. Change Setpoints
      f. View Trends
      g. Edit Schedules
   3. Engineer access level shall have the same access as Operator level with the ability to perform the following additional tasks:
      a. Add Devices
      b. Address Changes
      c. Create Applications
      d. Download Applications
      e. Configure ASCs
      f. Setup Trends
      g. Setup Reports
      h. Modify Alarm Settings

C. Provide security access level setup for 10 users. Coordinate user names, access levels and passwords with Laboratory.

D. System shall provide an Auto Logout Feature that shall automatically logout user when there has been no keyboard or mouse activity for 5 minutes. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal shall display message on screen that user is logged out after Auto Logout occurs.

3.5 DDC SOFTWARE INSTALLATION

A. Operating system: The Contractor shall install the OS on Engineering Workstation and configure user names and passwords.

B. Virus Protection software: The Contractor shall install the virus protection software on Engineering Workstation and shall configure weekly virus scans.

C. Contractor shall install and configure all software packages required to maintain and configure all types of controllers provided as part of this project on the Engineering Workstation:

D. Software from panels shall be permanently stored on CD/DVD, on the Engineering Workstation and on Web Application Server.

E. Provide auto re-boot feature on power up from system failure. System failures shall not necessitate manual reprogramming to restore normal system function.

F. Provide latest version of standard software, including operating system and control software. Include software updates for period after system acceptance, coinciding with warranty period. Beta released software shall not be used.

3.6 INITIAL PROGRAMMING

A. General

1. Control Contractor shall provide initial programming of controllers and network to accomplish sequences specified.
2. Provide back-up documentation per software manual submittals for programs, in both written and electronic media formats.
3. Provide programming of menus to assist new users in accessing screen displays of each point group. Point groups (user definable) shall be initially arranged by DDC for major equipment and by floor and area for terminal devices. Field/floor level devices shall also be grouped by air handling system where applicable.

B. BACnet Naming and Addressing

1. Every BACnet device shall have an assigned and documented MAC Address unique to its network. For Ethernet networks, document the MAC Address assigned at its creation. For MS/TP, assign from range as indicated by vendor documentation.
2. Assign unique numbers to each new network installed on the BACnet internetwork. Provide ability for changing the network number; either by device switches, network computer, or field operator interface. The BACnet internetwork (all possible connected networks) can contain up to 65,534 possible unique networks.
3. Every BACnet Building Controller (B-BC) and BACnet Router UDP port number shall be set to 47808 (BAC0).
4. Assign unique Device "Object_Identifier" property numbers or device instances for each device on the BACnet internetwork. Provide for future modification of the device instance number; either by device switches, network computer, or field interface.
5. The Object Name property field shall support 32 minimum printable characters. Assign Object Name properties with plain-English names descriptive of the application. Examples include "Zone 1 Temperature" and "Fan Start/Stop".

C. Minimum BACnet Object Requirements

1. For the following points and parameters, use standard BACnet objects, where all relevant object properties can be read using BACnet's Read Property Service, and all relevant object properties can be modified using BACnet's Write Property Service: all device physical inputs and outputs, all set points, all PID tuning parameters, all calculated pressures, flow rates, and consumption values, all alarms, all trends, all schedules, and all equipment and lighting circuit operating status.
2. The Object Description property shall support 32 minimum printable characters. For each object, complete the description property field using a brief, narrative, plain English description specific to the

object and project application. For example: "HW Pump 1 Proof." Document compliance, length restrictions, and whether the description is writeable in the device PICS.

3. Support and provide Description and/or Device Type text strings matching signal type and engineering units shown on the points list.
4. Support and provide Inactive Text and Active Text property descriptions matching conditions shown on the points list.
5. For devices with scheduling capability, provide at least one Calendar Object with ten-entry capacity. Enable the writeable Date List property and support all calendar entry data types.
6. Use Schedule Objects for all building system scheduling.
7. Use Loop Objects or equivalent BACnet objects in each applicable field device for PID control. Regardless of program method or object used, allow authorized operators to adjust the Update Interval, Setpoint and all constraints associated with Object, such as Proportional Constant, Integral Constant, and Derivative Constant for Loop Object, using BACnet read/write services.

D. Minimum BACnet Service Requirements

1. Use commandable BACnet objects to control machinery and systems, providing the priority levels listed below.

Priority Level	Application
1	Manual-Life Safety
2	Automatic-Life Safety
3	(User Defined)
4	(User Defined)
5	Critical Equipment Control
6	Minimum On/Off
7	(User Defined)
8	Manual Operator
9	(User Defined)
10	(User Defined)
11	Load Shedding
12	(User Defined)
13	(User Defined)
14	(User Defined)
15	(User Defined)
16	(User Defined)

E. Data Sharing:

1. Data communication from Building Controllers to Engineering Workstation and BAS web server shall be programmed to use Change of Value (COV) data sending and not continuous data polling to limit net work traffic.
2. Data communication parameters for analog values shall be operator configurable and setup as follows:
   a. Minimum Send Time: 2 seconds
   b. Maximum Send Time: 60 seconds
   c. Send on Delta (COV) :
      1). Space Temperature: ±0.5°F
      2). Process Temperature: ±0.5°F

3). Air Pressure, AHU: ±0.05 “W.C.

4). Relative Humidity: ±1%

5). Air Flow: ±2% of range

6). Water Flow: ±2% of range

7). Water Pressure ±0.5 psi

3. Digital data points shall be sent whenever a state change occurs.

F. Historical Trending:

1. All analog inputs and outputs shall be trended and trends shall be fully configured and operational. Initial sample time shall be one minute (FA).
2. Trend logs are to be stored at the building controllers and uploaded to the BAS web server when the building controller trend buffer size reaches 80% full or every 60 minutes (FA).

G. Alarm/Event Management:

1. All alarm handling shall be fully configured with consistent alarm messages and priorities or category numbers to identify the system from which the alarm originates.
2. Program maintenance alarms based on run-times and quantity of start/stops for motor driven equipment.
3. Provide the following additional alarms:
   a. Controller loss of communications for each controller.
   b. Controller battery alarm for each controller (where available)
   c. Out-of-range, bad, or missing data (fault) for each device.
4. Event Notification Message Texts - Use condition specific narrative text and numerical references for alarm and event notification.
5. Program alarms using the following levels:
   a. Level 1 - Maintenance Alarm, requiring attention within 1 to 2 days. (Examples: 2-3°F temperature variance from set point; 5-10% relative humidity variance; etc.)
      1). Coordinate alarm setpoints with Laboratory.
6. Level 2 - Low /High Level Alarm, requiring attention within 8 hours, preferably during same shift. (Examples: More than 3°F variance from set point, 30 percent relative humidity or more variance from set points; excess start/stops per day; etc.)
      1). Coordinate alarm setpoints with Laboratory.
7. Level 3 - Critical Alarm, requiring immediate attention. (Examples: Non-operation of primary equipment; failure of controllers, routers and repeaters.)

H. Time Schedules:

1. Provide time schedules for HVAC components/systems as indicated in Control Sequences.
2. All time schedules shall be fully configured with weekly schedules and all holidays identified by the Laboratory.
3. Time schedules are to reside in the Building Controllers.

3.7 POINT LIST

A. Provide points required to implement control sequences specified, whether or not they are listed in schedules. In addition to control points, provide additional points listed in point schedules or defined in Control Sequences.

B. All points shall be programmed with a point name and detailed description. Control contractor shall submit point naming convention to Laboratory/Engineer for approval prior to system programming.

3.8 STARTUP

A. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.9 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

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SECTION 23 09 24

GRAPHICAL USER INTERFACE INTEGRATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 09 01 - Control Systems Integration

B. Section 23 09 23 - Direct Digital Controllers and Networks

1.2 SYSTEMS DESCRIPTION

A. Building Automation System (BAS) Graphical User Interface (GUI) shall be accomplished via a web-server environment.

B. The Building Campus currently has an existing Johnson Controls BAS Web server which provides system monitoring, alarming, scheduling, reporting and historical trend functions via graphical user interface.

C. BAS Contractor shall integrate the new BAS provided under Section 23 09 23 to the existing BAS Web Application Server.

D. Provide remote alarm paging via text message, alphanumeric message and email via web server.

1.3 REFERENCE

A. The Work under this section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.4 SUBMITTALS

A. Refer to Section 23 09 01 - Control Systems Integration.

1.5 OPERATION AND MAINTENANCE MANUALS

A. Refer to Section 23 09 01 - Control Systems Integration.

1.6 RECORD DRAWINGS

A. Refer to Section 23 09 01 - Control Systems Integration.

1.7 OWNERSHIP OF PROPRIETARY MATERIAL

A. Refer to Section 23 09 01 - Control Systems Integration.

1.8 WARRANTY

A. Refer to Section 23 09 01 - Control Systems Integration.

PART 2 - PRODUCTS

2.1 BAS WEB APPLICATION SERVER – HARDWARE INTEGRATION INTO EXISTNG SERVER

A. Provide all hardware required to integrate the BAS into the existing Campus BAS Web Application Server for operator control/monitoring of building control systems.

2.2 BAS WEB SERVER – SOFTWARE INTEGRATION INTO EXISTING SERVER

A. Provide all necessary software upgrades or additional licenses to accommodate the additional point capacity required to integrate all BAS monitoring and controls points. Refer to specifications 23 09 05 – DDC Point Schedule and 23 09 93 – Control Sequences.

PART 3 - EXECUTION

3.1 GENERAL

A. Install all control equipment in neat and workmanlike manner to satisfaction of Architect and Engineer.

B. Coordinate timely delivery of materials and supervise installation of control devices.

C. Provide integration of all input / output points as defined in section 23 09 05 and 23 09 93 to the existing BAS Web Server and available for override from the respective BAS Web Server operator graphical interface. All setpoints, time delays, and other control parameters called out in the control sequences defined in section 23 09 93 as adjustable shall be integrated and available for override or adjustment from the respective BAS Web Server operator graphical interface.

D. All alarms, trending, schedules shall be through standard BACnet objects and shall not utilize proprietary software that would be incompatible with ANSI/ASHRAE Standard 135-2001 BACnet technology communication protocol.

E. Software naming conventions shall be kept consistent with the existing Site Building Automation Network. Consult with the Argonne prior to database generation to ensure naming conventions are acceptable and approved by the designated representative. If approval is not obtained, Argonne requested revisions to the software shall be made at no charge.

3.2 BAS WEB SERVER – SOFTWARE PROGRAMMING

A. Alarm and Event Management:
   1. Web Server Software shall be programmed to receive BACnet alarm event notifications from individual controllers and manage system alarm/event notification and routing.
   2. Web Server Software shall be programmed to monitor status of each IP-based controller and provide alarms on loss of communication/status.
   3. Operator shall be able to adjust alarm limits if logged on with the appropriate security access.

B. Scheduling:
   1. Web Server Software shall be programmed to provide scheduling interface for individual HVAC system Occupied/Unoccupied operation as indicated in Control Sequences.
   2. Operator shall be able to change all information for a given schedule if logged on with the appropriate security access.

C. Trending & Data Archiving:
   1. Trend logs are not to be server based using polling. Trend logs are to be initially stored at the DDCP's and periodically uploaded to the Web Server data historian for long-term storage.
   2. Web Server shall provide data archiving for all analog inputs, analog outputs and calculated energy data.
   3. Archived data shall be maintained for a minimum of two years.
   4. All trend log information shall be displayed in standard engineering units.
   5. Data points indicated to as "LEED M&V" in the DDC Point Schedules shall be have a sampling time of one minute and averaged over 15 minutes.

D. Report Generating:
   1. Web Server Software shall be programmed with commands to generate and format the following reports for displaying on current Workstation, printing, and storing on disk:
      a. Energy usage Report: An energy usage summary, operator selectable, for each air handling unit and building. The report shall be divided by utility, and shall be capable of reporting on at least four separate utilities. The report shall include the following information:
         1). Beginning and ending dates and times.
         2). Total energy usage for each utility for the current and previous day.
         3). Total energy usage for each utility for the current and previous month.
         4). Maximum 15-minute interval average rate of consumption for each utility for the current and previous day and current and previous month.
         5). Average Outside air (OA) temperature and OA relative humidity (RH) for current and previous month and current and previous day.
         6). Calculated degree days.
      b. Current Alarm Summary Report: Current alarms by building or unit, including time of occurrence.
      c. Daily Alarm Summary Report: Current alarms by building or unit, including time of occurrence for a user specified day.
      d. Daily Room Summary Report: Average, high & low values for temperature, humidity and air change rate for a user specified day.
      e. Override Report: Points overridden, including time overridden, and identification of operator overriding the point.
      f. Run Time Reports: A report totalizing the accumulated run time of individual pieces of equipment. The operator shall be able define equipment groupings and shall be able to generate reports based on these groupings.
      g. LEED Measurement & Verification (M&V) Report: Full listing of all trend data points designated for M&V over a user definable one year period of time. Data shall be provided in a format compatible with Microsoft Office Excel.
      h. Provide allowance for two (2) additional Government defined custom reports.

3.3 GRAPHICS PROGRAMMING

A. All proposed graphic displays shall be presented to the Owner for approval prior to implementation.

B. Navigation Scheme: System graphic displays of HVAC, plumbing and electrical systems and points shall be hierarchical displays using a building-to-equipment point-and-click navigation scheme. Each display shall show the building/Area name and number.

C. Program color graphic displays for each system as described herein. Graphic displays shall consist of pictorial presentations with text description, system schematic, or picture; alarm fields; and database fields for associated points, including dynamic input values, output values, set points, gains, time schedules, etc.

D. Graphics shall be configured to automatically update values without any action by the operator.

E. All standard graphic features, such as title block, navigation buttons, etc., shall always be located in the same general area on each Graphic. For example, the navigation buttons shall always start at the left frame of the graphic. The Home, Charts and Alarm buttons shall always start in the upper right corner of the graphic.

F. A description of a point shall be included on the Graphic next to the object's value whenever there is any ambiguity about the value's meaning. For example, when status and command points are both shown on a Graphic, they shall both be labeled with separate identifying descriptions. If a description of a point in a point block in not adequate, then a separate Note may be added to the Graphic Background near the point block clarifying function or purpose. This shall prevent any confusion about what a value represents.

G. Display time, date, outside temperature and humidity on each display in same location on each graphic. Provide command to direct specific displays without accessing main menu. Provide means of displaying directory of screens. Arrange displays by group and type.

H. Graphic displays shall be designed to be easily understood. When display screen is too cluttered due to size, limit information to important monitoring data. Provide sub-graphic(s) to display data not displayed on main display.

I. Each graphic shall have a shortcut to the main menu graphic and to previous graphic.

J. Main menu graphic shall be automatically displayed when user logs on to system.

K. Graphics shall include, but not be limited to:
   1. Site Plans, including each building, building name, and status of exterior points such as lighting, etc.
   2. Overall building plan. Indicate location of mechanical rooms and areas served by each air handling unit.
      a. Provide link from building plan to individual building floors and mechanical rooms.
   3. Overall HVAC floor plan of each Area/Floor with indication of individual space temperatures, CO2 levels, occupancy status, equipment status, equipment locations and alarm status for displayed values. Include room names and numbers for all spaces on floor plan graphics.
      a. Provide link from displayed values and equipment to associated equipment or operator interface graphic.
      b. Provide link to overall building plan.
      c. Label equipment and displayed values according to mechanical floor plans and BAS program.
   4. Schematic type graphics for:
      a. Main Menu, with background digital picture of building, which shall have direct links to each of the following:
         1). Overall Building Plan
         2). Heating Hot Water System
         3). Each Air Handling Unit (AH)
         4). Power Monitoring/Standby Power Generators
         5). Each HVAC Floor Plan
         6). Plumbing Systems
         7). BAS Network Architecture
      b. Each Air Handling Unit (AH)
         1). Supply fan control loops
         2). Return fan control loops
         3). Cooling coil control loops

4). Heating coil control loops

5). Damper control loops

c. Exhaust Air Systems

d. Fan Coil Units

e. Unit Heaters & cabinet Unit Heaters

f. Air Terminals

g. Heating hot water system showing all components and control loops

h. Power monitoring and Standby Power Generator

i. Each Plumbing System

j. BAS Network Architecture indicating status of all devices/controllers

k. HVAC Schedules

l. Trends

m. Reports

5. Provide allowance for an additional five (5) Owner defined graphic pages.

3.4 STARTUP

A. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.5 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

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SECTION 23 09 93

CONTROL SEQUENCES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 09 01 - Control System Integration

B. Section 23 09 02 - Control Valves and Dampers

C. Section 23 09 03 - Control Instrumentation

D. Section 23 09 05 - Instrument Point List

E. Section 23 09 23 - Direct Digital Controllers and Networks

F. Section 23 09 24 - Graphical User Interface Integration

1.2 PRESSURE TRANSMITTER/SENSORS

A. Pressure transmitter/sensors shall be hardwired directly back to the BAS controller that provides control signal to the VFD(s). Sharing the static pressure signal via the network shall not be allowed for control.

1.3 PROGRAM REQUIREMENTS

A. All control set points, time sequence values, etc. shall be adjustable either at the local sensor or via workstation variables.

B. All workstation variables/setpoints used for control shall be adjustable by operator unless otherwise noted.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Refer to sections stated under related work.

PART 3 - EXECUTION

3.1 GENERAL CONTROL SEQUENCE

A. Switch point actuation

1. Provide each switch/alarm trip point with an adjustable time delay to prevent nuisance tripping. These time delays apply to all switch points whether hardware or software and for normal operation. Additional or longer delays may be necessary during start-up or shut down as noted herein.
2. Unless otherwise specified, the time delay shall be as follows:

a.	Process or operation	time delay
b.	Flow	5 second
c.	Motor starter	5 second
d.	Liquid pressure	3 seconds
e.	Gas pressure	3 seconds
f.	Differential pressure	20 seconds

g. Valve limit switch 60 seconds

h. Temperature indoor 1 minute

3. If the time delays are less than the controller scan rate, the minimum controller scan rate shall be the time delay.

B. VFD Minimum Speed:

1. The VFD start-up technician shall work with Control Contractor to determine the minimum speed required for motors controlled by the VFD to provide cooling of the motor as installed to prevent heat related problems. This minimum speed shall be set in the VFD controller. The VFD start-up technician shall wok with the Control Contractor to set the acceleration and deceleration timers in the VFD controller at 30 seconds for motors less than 40 HP and 60 seconds for motors 40 HP and greater.

3.2 CONTROL SEQUENCES COORDINATION

A. Systems shall perform in accordance with control sequences. Refer to system diagrams, flow diagrams and related drawings for overall system arrangements. Provide all control devices and instrumentation required to perform the sequences whether or not specifically shown on the drawings.

B. Review and coordinate with shop drawings and submittals of controlled and monitored equipment and provide required control devices and wiring for proper interface and system integration. This shall include energy recover wheels, transfer switches and any other equipment provided with factory furnished control and monitoring devices.

3.3 LOW TEMPERATURE HEATING WATER SYSTEM - CONTROL SEQUENCE

A. General

1. System consist of the following pumps:

a. HWP-3

b. HWP-4

2. The APCF low temperature heating water (LTW) is supplied from the main APS low temperate heating water system.
3. Water is distributed to the APCF and two heat recovery plate and frame heat exchangers by two variable flow secondary low temperature heating water pumps located in LOM 435 penthouse. The pumps are each sized at 100% with one pump operating continuously with the other pump as standby.
4. Low temperature heating water system will serve reheat coils, fan coil units, unit heaters, cabinet unit heaters, radiant ceiling panels and chilled beam heating pumps.
5. A flow meter will monitor and report energy, temperature and flow.
6. Variable flow pump arrangement is used for low temperate heating water pumping system.
7. Above shall include all work on system interlocking, operation and capacity control.
8. Refer to drawing MI5.1.4.

B. Low temperature heating water pump operation

1. Two low temperature heating water pumps (HWP-1 and HWP-2) are sized for 100% capacity and are piped in parallel.
2. Low temperature heating water pump(s) shall be started and stopped automatically.
3. Equalize run time on pumps based on accumulated run time (FA). When lead pump total operating hours exceeds total operating hours of lag pump by 1000 hours, original lag pump shall become new lead pump, original standby pump shall become new lag pump, and original lead pump shall become new standby pump. Switch-over of lead, lag, and standby pumps shall occur Tuesdays at 11 AM (FA).

4. Whenever primary pump fails as proven by lead pump VFD fail mode output, differential pressure or loss of flow, standby secondary pump shall start, failed pump shall be de-energized, and an alarm shall be annunciated at the workstation.
5. Pump speed shall modulate between minimum (25% or 15 Hz) and maximum speeds (93% or 56 Hz*) to maintain constant differential pressure (18 ft, 7.8 psi) at one differential pressure transmitter located in supply and return lines near end of system as shown on drawings.
6. Final maximum speed and pressure setpoint to be determined by TAB contractor.
7. Modulate by-pass valve to maintain minimum flow, 25% of total pump flow.

C. Low Temperature Heating Water Temperature Control
1. Low temperature heating hot water control valve, located on building return main, shall modulate to maintain a constant 180°F (FA) low temperature hot water supply temperature downstream of HWP-1 and HWP-2.

D. Failure Mode
1. Pumps are served by standby power with only one pump operating when on standby power. Pumps and control sequences shall automatically restart upon resumption of normal or standby power.
2. On loss of signal or transmitter failure, pump shall be controlled at the last known speed and BAS shall annunciate an alarm.

E. BAS shall annunciate an alarm at the workstation.
1. Generate alarms as indicated:
a. VFD Fault – each pump
1). Generate alarm
b. Heating water supply temperature
1). Generate alarm if heating water supply temperature is ±5°F of setpoint for five consecutive minutes.
c. Differential pressure sensor
1). Generate alarm if pressure is ± 2 psi of setpoint for 5 consecutive minutes.
d. Flow sensor
1). Generate alarm if flow is less than minimum flow setpoint for 2 consecutive minutes.

3.4 CHILLED BEAM PUMPING HEATING WATER SYSTEM - CONTROL SEQUENCE

A. General:
1. System consist of the following pumps:
a. HWP-5
b. HWP-6
2. System is designed for variable flow with VFDs on both pumps. Each pump is designed for 100% of the total design chilled beam chilled water flow with one pump operating with the other pump as standby.
3. Chilled beam pump system provides heating hot water to chilled beams at a temperature lower than low temperature water.
4. Variable flow pump arrangement is used for chilled beam heating water pumping system.
5. Above shall include all work on system interlocking, operation and capacity control.
6. Refer to drawing MI5.1.4

B. Chilled Beam Pumping System
1. Chilled beam pumps shall operate in lead-standby sequence and are piped in parallel.

2. Pump(s) shall run continuously when the space temperature of any room with chilled beams is calling for heating.
3. Equalize run time on pumps based on accumulated run time (FA). When lead pump total operating hours exceeds total operating hours of lag pump by 1000 hours, original lag pump shall become new lead pump, original standby pump shall become new lag pump, and original lead pump shall become new standby pump. Switch-over of lead, lag, and standby pumps shall occur Tuesdays at 11 AM (FA).
4. Whenever primary pump fails as proven by lead pump VFD fail mode output or loss of flow, standby secondary pump shall start, failed pump shall be de-energized, and an alarm shall be annunciated at the workstation.
5. Pump speed shall modulate between minimum (25% or 15 Hz) and maximum speeds (93% or 56 Hz*) to maintain constant differential pressure (18 ft, 7.8 psi) at one differential pressure transmitter located in supply and return lines near end of system as shown on drawings.
6. Final maximum speed and pressure setpoint to be determined by TAB contractor.
7. Modulate by-pass valve to maintain minimum flow, 25% of total pump flow.

C. Chilled Beam Heating Water Temperature Control
1. Low temperature heating hot water control valve shall modulate to maintain a constant 120°F (FA) chilled beam hot water supply temperature.

D. Failure Mode
1. Pumps are served by standby power with only one pump operating when on standby power. Pumps and control sequences shall automatically restart upon resumption of normal or standby power.
2. On loss of signal or transmitter failure, pump shall be controlled at the last known speed and BAS shall annunciate an alarm.

E. BAS shall annunciate an alarm at the workstation.
1. Generate alarms as indicated:
a. VFD Fault – each pump
1). Generate alarm
b. Chilled beam heating water supply temperature
1). Generate alarm if chilled beam heating water supply temperature is ±5 ^{o}F of setpoint for five consecutive minutes.
c. Differential pressure sensor
1). Generate alarm if pressure is ± 2 psi of setpoint for 5 consecutive minutes.
d. Flow sensor
1). Generate alarm if flow is less than minimum flow setpoint for 2 consecutive minutes.

3.5 MAGNET WATER HEAT RECOVERY SYSTEM - CONTROL SEQUENCE

A. General
1. System consist of the following pumps:
a. HWP-3
b. HWP-4
c. MCP-1
d. HX-1
e. HX-2
f. HX-3
2. The APCF heat recovery water (HR) is supplied from the main APS magnet cooling system and the low temperature heating water system.

3. Magnet dionized water is distributed to one heat exchanger located in the LOM penthouse, warm side with heat recovery water is distributed to same heat exchanger, cold side. Two variable flow heat recovery heating water pumps located in APCF penthouse circulate the water to AHU's heating coils. Pumps are each sized at 100% with one pump operating continuously with the other pump as standby.
4. Heat recovery return water absorbs heat from magnet system and is distributed to two 100% heat exchangers located in LOM 435 penthouse, cold side. Low temperature heating water provide addition heat through the same heat exchangers, hot side.
5. Magnet cooling water and heat recovery water flow meters will monitor and report energy, temperature and flow.
6. Refer to drawing MI5.1.4.

B. Heat Recovery water pump operation
1. Two heat recovery water pumps (HWP-3 and HWP-4) are sized for 100% capacity and are piped in parallel.
2. Heat recovery water pump(s) shall be started and stopped automatically and shall run continuously when the outside air temperature is below 50°F.
3. Heat exchanger valve HX-1 or HX-2 shall be proven open via end switch before HWP-3 or HWP-4 pump starts.
4. Equalize run time on pumps based on accumulated run time (FA). When lead pump total operating hours exceeds total operating hours of lag pump by 1000 hours, original lag pump shall become new lead pump, original standby pump shall become new lag pump, and original lead pump shall become new standby pump. Switch-over of lead, lag, and standby pumps shall occur Tuesdays at 11 AM (FA).
5. Whenever primary pump fails as proven by loss of flow or lead pump VFD fail mode output, standby secondary pump shall start, failed pump shall be de-energized, and an alarm shall be annunciated at the workstation.
6. Pump speed shall modulate between minimum (25% or 15 Hz) and maximum speeds (93% or 56 Hz*) to maintain constant differential pressure (18 ft, 7.8 psi) at one differential pressure transmitter located in supply and return lines near end of system as shown on drawings.
7. Final maximum speed and pressure setpoint to be determined by TAB contractor.
8. Modulate by-pass valve to maintain minimum flow, 25% of total pump flow.

C. Magnet Cooling water pump operation
1. One magnet cooling water pump (MCP-1) is sized for 100% capacity with no back-up.
2. When HWP-3 and HWP-4 are commanded to operate, MCP-1 shall operate. Provide software switch, located on system graphic, which shall provide operator ability to disable pump operation and initiate magnet cooling heat exchanger bypass mode (see section below).
3. Magnet cooling water pump inlet isolation valve shall be proven open via end switch before magnet cooling water pump starts.
4. Whenever pump fails as proven by loss of flow or pump VFD fail mode output, pump shall be de-energized, and an alarm shall be annunciated at the workstation.
5. Pump speed shall remain constant when magnet cooling pump is in operation.

D. Magnet Cooling Heat Exchanger operation
1. One magnet cooling heat exchanger (HX-3) is sized to reject heat from the APS magnet cooling water system in the heat recovery loop.
2. During normal operation, bypass valve shall be closed.
3. When system is in Bypass mode, bypass valve shall be opened and position proven via end switch.

E. Heat Recovery Heat Exchanger operation

1. Two heat recovery heat exchangers (HX-1 and HX-2) are each sized for 100%, to provide heat from the APS low temperature heating water system to the heat recovery loop.
2. One heat exchanger shall operate at a time with the other heat exchanger for stand-by. Valve associated with stand-by heat exchanger shall be closed when heat exchanger is not in operation.
3. Upon drop in heat recovery supply temperature below 120°F (FA) valve associated with operating heat exchanger shall be open. Low temperature heating valve associated with operating heat exchanger shall modulate to maintain 120°F (FA) heat recovery supply temperature.
4. BAS program shall change the primary heat exchanger every 1000 hours of operation to achieve equal run time on equipment.
5. Whenever heat exchanger associated valve fails as proven by end switch, standby heat exchanger shall open after 30-second time delay, and an alarm shall be annunciated at the workstation.

F. Failure Mode
1. Pumps (HWP-3 and HWP-4) are served by standby power with only one pump operating when on standby power. Pumps and control sequences shall automatically restart upon resumption of normal or standby power.
2. On loss of signal or transmitter failure, pump shall be controlled at the last known speed and BAS shall annunciate an alarm.

G. BAS shall annunciate an alarm at the workstation.
1. Generate alarms as indicated:
   a. VFD Fault – each pump
      1). Generate alarm
   b. Heat recovery water supply temperature
      1). Generate alarm if heat recovery water supply temperature is ±5 ^{o}F of setpoint for five consecutive minutes.
   c. Differential pressure sensor
      1). Generate alarm if pressure is ± 2 psi of setpoint for 5 consecutive minutes.
   d. Heat recovery water flow sensor
      1). Generate alarm if flow is less than minimum flow setpoint for 2 consecutive minutes.
   e. Magnet cooling water flow sensor
      1). Generate alarm if flow is less than minimum pump flow for 2 consecutive minutes.

3.6 CHILLED WATER SYSTEM - CONTROL SEQUENCE

A. General:
1. System consist of the following pumps:
   a. CHP-1
   b. CHP-2
2. The APCF chilled water is supplied from the main APS chilled water system.
3. Water is distributed by two variable flow secondary chilled water pumps located in LOM 435 penthouse. The pumps are each sized at 100% with one pump operating continuously with the other pump as standby. Chilled water is provided to air handling units, fan coil units, environmental condensing units and chilled beam system pumps.
4. Above shall include all work on system interlocking, operation and capacity control.
5. Modulate valve on bridge piping to maintain secondary supply water temperature set point as sensed by temperature sensor on secondary chilled water supply downstream of CHP-1 and CHP-2. Set point shall be set 2 ^{o}F (FA) higher than chilled water temperature higher than supplied by central plant cooling system. Central plant supply water temperature shall be obtained through existing control system. Set point shall be limited to 42 ^{o}F (FA) minimum.

6. Refer to drawing MI5.1.3.

B. Chilled Water Pumps Operation:
1. Chilled water pumps (CHP-1 and CHP-2) circulate chilled water to the air handling unit coils, fan coils, environmental room condensing units and chilled beam cooling system. Each pump is sized for 100% of system normal flow. One pump is required for normal operation; the second pump is standby. Each pump has its own variable frequency drive (VFD) with bypass starter.
2. Chilled water pumps shall operate in lead-standby sequence and are piped in parallel.
3. The lead chilled water pump shall run continuously to maintain flow to environmental rooms. Modulate by-pass valve to provide minimum flow of 150 GPM from lead pump.
4. The standby pump shall run when the primary pump fails to meet differential pressure at the end of the system or if the primary pump fails to start after 2 minutes.
5. BAS program shall prompt operator to change the primary secondary pump every 28 days of operation on Mondays to achieve equal wear on equipment.
6. Whenever pump fails, as proven by VFD fail mode output, differential pressure, or loss of flow, standby secondary pump shall start, failed pump shall be de-energized, and an alarm shall be annunciated at the workstation.
7. Pump speed shall modulate between minimum (25% or 15 Hz) and maximum speeds (93% or 56 Hz*) to maintain constant differential pressure (18 ft, 7.8 psi) at one differential pressure transmitter located in supply and return lines near end of system as shown on drawings.
8. Final maximum speed and pressure setpoint to be determined by TAB contractor.
9. Modulate by-pass valve to maintain minimum flow, 25% of total pump flow.

C. Failure Mode
1. Pumps are served by standby power with only one pump operating when on standby power. Pumps and control sequences shall automatically restart upon resumption of normal or standby power.
2. On loss of signal or transmitter failure, pump shall be controlled at the last known speed and BAS shall annunciate an alarm.

D. BAS shall annunciate an alarm at the workstation.
1. Generate alarms as indicated:
   a. VFD Fault – each pump
      1). Generate alarm
   b. Chilled water supply temperature
      1). Generate alarm if chilled water supply temperature is ±5 ^{o}F of setpoint for five consecutive minutes.
   c. Differential pressure sensor
      1). Generate alarm if pressure is ± 2 psi of setpoint for 5 consecutive minutes.
   d. Flow sensor
      1). Generate alarm if flow is less than minimum flow setpoint for 2 consecutive minutes.

3.7 CHILLED BEAM PUMPING CHILLED WATER SYSTEM - CONTROL SEQUENCE

A. General:
1. System consist of the following pumps:
   a. CHP-3
   b. CHP-4
2. System is designed for variable flow with VFDs on both pumps. Each pump is designed for 100% of the total design chilled beam chilled water flow with only one pump with the other pump as standby.

3. Chilled beam pump system provides chilled water to chilled beams at a temperature above the interior space dew point.
4. Above shall include all work on system interlocking, operation and capacity control.
5. Refer to drawing MI5.1.3

B. Chilled Beam Pumping System
1. Chilled beam pumps shall operate in lead-standby sequence and are piped in parallel.
2. Pump(s) shall run continuously when the space temperature of any room with chilled beams is calling for cooling.
3. Equalize run time on pumps based on accumulated run time (FA). When lead pump total operating hours exceeds total operating hours of lag pump by 1000 hours, original lag pump shall become new lead pump, original standby pump shall become new lag pump, and original lead pump shall become new standby pump. Switch-over of lead, lag, and standby pumps shall occur Tuesdays at 11 AM (FA).
4. Whenever primary pump fails as proven by loss of flow or lead pump VFD fail mode output, standby secondary pump shall start, failed pump shall be de-energized, and an alarm shall be annunciated at the workstation.
5. Pump speed shall modulate between minimum (25% or 15 Hz) and maximum speeds (93% or 56 Hz*) to maintain constant differential pressure (18 ft, 7.8 psi) at one differential pressure transmitter located in supply and return lines near end of system as shown on drawings.
6. Final maximum speed and pressure setpoint to be determined by TAB contractor.
7. Modulate by-pass valve to maintain minimum flow, 25% of total pump flow.

C. Chilled Beam Temperature Control
1. Chilled water return control valve on chilled water return shall modulate to maintain a constant 58°F (FA) secondary chilled water supply temperature.
2. Upon a cold start (air handling unit systems off for 30 minutes or more), chilled beam return water valve shall be closed for a period of 60 seconds before valves are allowed to modulate to maintain 65°F for the first 30 minute, then decrease temperature 1°F per 30 minutes until set point is achieved.
3. Upon a warm start (air handling unit systems off for less than 30 minutes), chilled beam return water valve shall remain in the last known position for a period of 60 seconds before valve is allowed to modulate.

D. Failure Mode
1. When normal power is reestablished pump shall return to normal operation.
2. On loss of signal or transmitter failure, pumps shall be controlled at the last known speed and BAS shall annunciate alarm.

E. BAS shall annunciate an alarm at the workstation.
1. Generate alarms as indicated:
   a. VFD Fault – each pump
      1). Generate alarm
   b. Chilled beam cooling water supply temperature
      1). Generate alarm if chilled beam cooling water supply temperature is ±5 ^{o}F of setpoint for five consecutive minutes.
   c. Differential pressure sensor
      1). Generate alarm if pressure is ± 2 psi of setpoint for 5 consecutive minutes.
   d. Flow sensor
      1). Generate alarm if flow is less than minimum flow setpoint for 2 consecutive minutes.

3.8 CHILLED BEAM (HEATING AND COOLING)- CONTROL SEQUENCE

A. See air terminal control sequence for requirements.

3.9 RADIANT CEILING HEATING PANELS - CONTROL SEQUENCE

A. A space thermostat shall modulate control valve (FLP) to each unit to maintain space set point temperature.

3.10 UNIT HEATERS - CONTROL SEQUENCE

A. Space thermostat shall modulate control valve (FLP) in supply line to each unit to maintain space set point temperature. Line voltage aquastat shall start unit fan on rise in return line temperature above preset temperature of 100°F (FA) and stop fan on drop below set temperature.

3.11 CABINET UNIT HEATERS - CONTROL SEQUENCE

A. Space thermostat shall modulate control valve (FLP) in supply line to each unit to maintain space set point temperature. Line voltage aquastat shall start unit fan on rise in return line temperature above preset temperature of 100°F (FA) and stop unit fan on drop below set temperature.

3.12 FAN COIL UNITS (HEATING/COOLING AND COOLING ONLY) - CONTROL SEQUENCE

A. BAS shall modulate 2-way control valves on hot and chilled water coils to provide heating or cooling to maintain space temperature of 72°F (FA) for occupied spaces and 80°F (FA) for non occupied spaces, mechanical, electrical, elevator equipment room, etc. IT rooms to be maintained so that supply air into the front of the server is no greater than 70°F (FA).

B. Valves shall be sequenced so that cooling valve will not open until heating valve is closed and vice versa.

C. Mode control:
   1. System has two modes of operation, occupied and unoccupied.
   2. Consider space occupied Monday through Friday from 7 am until 6 pm (FA). Consider space unoccupied at all other times.
   3. Fans shall operate whenever either valve is more than 10% open (FA).

3.13 ENVIRONMENTAL ROOM - CONTROL SEQUENCE

A. General:
   1. System consists of the following:
      a. Chilled water supply and return valves
      b. Domestic water valve and drain valve
   2. System is designed for constant flow with environmental room controller modulating for capacity control.
   3. Above shall include all work on system interlocking and operation.
   4. Refer to drawing MI5.1.3

B. Valve control
   1. Chilled water valves shall close upon loss of flow as detected at chilled water pumps.
   2. domestic water and drain valve shall open upon loss of chilled water flow. Valves shall be interlock so that domestic water and drain valves cannot open until chilled water valve is proven closed via end switch.
   3. Upon return of chilled water flow the reverse shall happen.

C. BAS shall annunciate an alarm at the workstation.
   1. Generate alarms as indicated:
      a. Environmental room space temperature above setpoint.
         1). Generate alarm
      b. Environmental room system failure
         1). Generate alarm
      c. Environmental room system switch to redundant system
         1). Generate alarm

3.14 PRIMARY HUMIDIFIERS - CONTROL SEQUENCE

A. General:
   1. System consist of the following:
      a. H-1 (AHU-1)
      b. H-2 (AHU-1)
      c. H-3 (AHU-2)
      d. H-4 (AHU-2)
   2. Refer to drawing MI5.1.1

B. Each humidifier has packaged automatic control system furnished by the humidifier manufacturer as specified in Section 23 8413.

C. BAS shall provide control signal and enable/disable signal to humidifier controller.

D. Humidifier capacity shall be modulated to maintain a constant air handling unit discharge air humidity setpoint at humidity sensor located in AHU discharge downstream of humidifier. Discharge air humidity setpoint shall be reset by controlling humidity sensor between zero and 60% r.h. (fa).

E. Controlling humidity sensor for AHU-1 and AHU-2 shall be located in respective general exhaust ductwork main so that humidity in exhaust air is measured before exhaust air passes through heat recovery wheels, to maintain humidity at 30% RH (FA).

F. BAS shall disable humidifier when its associated supply fan is not running or supply airflow is less than 8,000 cfm (FA).

G. At outside air temperature above 50°F, humidifier shall become inoperative.

3.15 AIR TERMINAL DEVICES - CONTROL SEQUENCE

A. General
   1. All fume hood exhaust shall be operated as constant air volume (CAV) through constant volume exhaust air terminal.
   2. Provide monitors for fume hoods per specification 23 0923, which will provide local audible and visual alarm.
   3. Fume hood exhaust air terminals are venturi self actuated type and require no external control interface.

B. Reheat Coil Control
   1. BAS shall modulate control valve to each coil to maintain space set point temperature.
   2. Reheat coil control valves shall fail in last position

3. When system is on standby power, normal reheat coil control shall be initiated. Upon return to normal power normal reheat coil control shall be initiated.

C. Air Terminal Control Sequence "1" - Constant Volume Supply and Chilled Beam

1. General:
   a. Refer to drawing MI5.1.5
   b. System consists of constant volume supply air terminals providing primary air for multiple chilled beams, multiple active chilled beams with heating and cooling coils.
   c. Space shall have two operating modes.
      1). Consider space occupied Monday through Friday from 7 am until 6 pm (adjustable). Consider space unoccupied at all other times.
      2). During occupied mode air terminal shall go to maximum setting per schedule.
      3). During unoccupied mode air terminal and chilled water valve shall be closed.
      4). Space/system to return to occupied mode based upon time schedule or any respective individual space occupancy sensor. Occupancy sensors provided as part of building lighting control system. Coordinate occupancy sensor interface with electrical contractor.
2. On a rise in space temperature above cooling setpoint (75°F) (FA) , with the reheat hot water valve closed, the chilled beam chilled water valve shall modulate to maintain cooling space temperature setpoint.
3. When the chilled beam chilled water valve is closed, the space temperature shall drift between cooling and heating setpoints.
4. On a drop in space temperature below the heating setpoint (68°F) (FA), with the chilled beam chilled water valve closed, the chilled beam hot water valve shall modulate open. With rise in space temperature reverse sequence shall occur, with reheat valve closing first.
5. Upon single air handling unit operation all air terminal units serving chilled beams shall close.
6. Alarm:
   a. Generate alarms as indicated:
      1). Space Temperature
         a). Generate alarm at central BAS if space temperature exceeds ± 3°F of setpoint for a period of 5 minutes.
      2). Chilled water supply condensation sensor
         a). Generate alarm at central BAS and close chilled water control valve if dew point is within 3°F of chilled water setpoint.

D. Air Terminal Control Sequence "2" – Variable Volume serving fan coil units

1. General:
   a. Refer to drawing MI5.1.5
   b. System consists of variable volume supply air terminal serving fan coil units Fan coil units have heating and cooling coils. Air terminal serving FCU-C105 shall be constant volume.
   c. Space shall have two operating modes, with the exception of FCU-C105 which shall be considered occupied at all times.
      1). Consider space occupied Monday through Friday from 7 am until 6 pm (adjustable). Consider space unoccupied at all other times.
      2). During occupied mode air terminal shall modulate based on space CO_2 sensors.
      3). During unoccupied mode air terminal shall close and fan coil units shall cycle to maintain space temperature. Fans shall operate whenever either valve is more than 10% open (FA).
      4). Room to return to occupied mode upon activation of rooms automatic light control sensor. Controls contractor to integrate automatic light control sensor into BAS.

2. Air terminal shall modulate based on CO_2 sensors located within associated space. Refer to mechanical plans for locations.
3. Upon drop in CO_2 below 600 ppm (FA) air terminal shall modulate toward closed.
4. With rise in CO_2 reverse sequence shall occur.
5. Upon failure of either air handling unit air terminals shall close, except air terminal serving FCU-C105, which shall remain open.
6. BAS shall modulate FCU 2-way control valves on hot and chilled water coils to provide heating and cooling to maintain space temperature of 75°F cooling, 72°F heating (FA) for occupied spaces.
7. Valves shall be sequenced so that cooling valve will not open until heating valve is closed and vice versa.
8. BAS shall annunciate an alarm at the workstation.
   a. Generate alarms as indicated:
      1). Space Temperature
         a). Generate alarm at central BAS if space temperature exceeds ±3°F of setpoint for a period of 5 minutes.
      2). Space CO2 (each sensor)
         a). Generate alarm at central BAS if space CO2 exceeds 900 ppm (FA) for a period of 5 minutes.
      3). FCU Fan Run Status – each FCU
         a). Generate alarm if fan does not indicate running within 30 seconds of start command.

E. Air Terminal Control Sequence “3” - Constant Duct Variable Volume with Reheat Air Supply/Exhaust Tracking
1. General:
   a. Refer to drawing MI5.1.5
   b. Room consists of constant volume supply air terminal(s) with reheat and constant volume general exhaust air terminal(s).
   c. Space shall have two operating modes.
      1). Consider space occupied Monday through Friday from 7 am until 6 pm (adjustable). Consider space unoccupied at all other times.
      2). During occupied mode air terminal shall go to maximum setting per schedule.
      3). During unoccupied mode air terminal shall go to minimum setting per schedule.
      4). Room to return to occupied mode based upon time schedule or space occupancy sensor (provided by others). Coordinate occupancy sensor interface with electrical contractor.
2. Modulate reheat coil control valve to maintain space temperature setpoint (72°F FA).
3. Modulate exhaust air terminal(s) between minimum and maximum to maintain constant differential between supply and exhaust as indicated in schedules.
4. Monitor and Alarm:
   a. Generate alarms as indicated:
      1). Space Temperature
         a). Generate alarm at central BAS if space temperature exceeds ± 3°F of setpoint for a period of 5 minutes.

F. Air Terminal Control Sequence “4” - Constant Volume Supply with Reheat/General Exhaust Tracking and Fume Hood
1. General:
   a. Refer to drawing MI5.1.5

b. Room consist of constant volume supply air terminal with reheat coil, constant volume general exhaust air terminal and constant volume fume hood air valves.

c. Space shall have two operating modes.

1). Consider space occupied Monday through Friday from 7 am until 6 pm (adjustable). Consider space unoccupied at all other times.

2). During occupied mode air terminal shall go to maximum setting per schedule.

3). During unoccupied mode air terminal shall go to minimum setting per schedule.

4). Room to return to occupied mode based upon time schedule or space occupancy sensor (provided by others). Coordinate occupancy sensor interface with electrical contractor.

2. Modulate reheat coil control valve to maintain space temperature setpoint (72°F FA).

3. Modulate exhaust air terminal(s) between minimum and maximum to maintain constant differential between supply and exhaust as indicated in schedules.

4. Alarm:

a. Generate alarms as indicated:

1). Space Temperature (AI)

a). Generate alarm at central BAS if space temperature exceeds ±3°F of setpoint for a period of 5 minutes.

G. Air Terminal Control Sequence “5” - Constant Volume Supply/Exhaust Air Tracking and Chilled Beam

1. General:

a. Refer to drawing MI5.1.5

b. System consists of constant volume supply air terminals providing primary air for multiple chilled beams, multiple active chilled beams with cooling coils and constant volume general exhaust air terminal.

c. Space shall have two operating modes.

1). Consider space occupied Monday through Friday from 7 am until 6 pm (adjustable). Consider space unoccupied at all other times.

2). During occupied mode air terminal shall go to maximum setting per schedule.

3). During unoccupied mode air terminal shall go to minimum setting per schedule.

4). Room to return to occupied mode based upon time schedule or space occupancy sensor (provided by others). Coordinate occupancy sensor interface with electrical contractor.

2. On a rise in space temperature above cooling setpoint (72°F) (FA)with chilled beam heating water valve closed, the chilled beam chilled water valve shall modulate to maintain cooling space temperature setpoint.

3. When the chilled water valve is closed, the space temperature shall drift between cooling and heating setpoints.

4. On a drop in space temperature below the heating setpoint (68°F) (FA) with chilled beam chilled water valve closed, the chilled beam hot water valve shall modulate open.

5. With rise in space temperature reverse sequence shall occur, with reheat valve closing first.

6. Alarm:

a. Generate alarms as indicated:

1). Space Temperature

a). Generate alarm at central BAS if space temperature exceeds ± 3°F of setpoint for a period of 5 minutes.

b). Generate alarm at central BAS and close chilled water control valve if dew point is within 3°F of chilled water setpoint.

H. Building Pressure Control Exhaust Air Valve, EV-C102A (-D)

1. Building pressure control exhaust air valve, EV-C102A (-D), shall modulate to maintain building positive pressure as follows:
   a. BAS shall calculate total AHU supply airflow by totalizing air flows from each AHU.
   b. BAS shall calculate total building exhaust air flow by totalizing flow from each exhaust valve, including building pressure control exhaust valve, and from exhaust fans 3, 4 and 5.
   c. BAS shall modulate building pressure control exhaust air terminal to maintain total building exhaust 2000 cfm (FA) less than total supply air flow.

3.16 AIR HANDLING UNIT (AHU-1 AND AHU-2) - CONTROL SEQUENCE

A. General
1. Refer to drawing MI5.1.1
2. Air handling units AHU-1 and AHU-2 operate as single duct, variable volume, heating, cooling and energy recovery system with reheat. Systems are 100% outside air to provide outside air to the laboratory and office and exhaust air from the general laboratory and office exhaust.
3. Air handling units are factory fabricated units. Units consist of:
   a. OA intake section with two position outside air damper
   b. Prefilter
   c. Direct drive supply fan array with back draft dampers and variable speed drive
   d. Enthalpy type heat recovery wheel
   e. Supply and Exhaust enthalpy wheel by-pass damper
   f. Heating coil (Heat recovery system)
   g. Cooling Coil
   h. Exhaust filter
   i. Direct drive exhaust fan array with back draft dampers and variable speed drive
   j. Discharge supply and exhaust plenum with isolation damper
4. Supply air ducts will have smoke detectors upstream of smoke dampers provided by Electrical Contractor.
5. Two-position outside air dampers and exhaust dampers shall be furnished by Controls Contractor. Supply and exhaust enthalpy wheel by-pass damper provided with unit. Controls Contractor to provide damper actuator and associated controls.
6. Two-position isolation/smoke dampers, and control valves shall be furnished by Controls Contractor.
7. Chilled water control valves shall be 2-way type with (FLP) actuators.
8. Heat Recovery Hot water control valves shall be 2-way type with (FLP) actuators.

B. System and Fan Operation
1. Each unit has single operation mode and shall operate continuously.
2. System shall be automatically start/stop via BAS discrete output point.
3. When system is commanded to start , the following sequence shall occur:
   a. Outside air, exhaust air and supply smoke dampers for each respective unit shall open and prove their position via end switch.
   b. Supply and exhaust fans shall start together and slowly ramp up to minimum speed.
   c. Fan air volumes are then allowed to be controlled
4. When system is commanded to stop, all fans shall stop and the outside air, smoke damper/isolation and exhaust dampers shall close.
5. Interlocks

a. The following safety interlocks shall be accomplished through hardwired relay connections or auxiliary contacts and shall enable equipment or systems to operate when handling unit supply fan is on.

b. Smoke detectors in the air handling unit discharge.

c. High and low pressure switches

d. Exhaust fans EF-1 through EF-5 shall be interlocked with supply fans SF-1 and SF-2 respectively so that exhaust fans operate whenever its associated supply fan operates. Exhaust fan shall start before associated supply fan is allowed to start.

e. Interlock associated humidifier(s) so that humidifier(s) will be inoperative when the following conditions occur.

1). Unit supply fan is not operating or air flow, as indicated by supply airflow measuring station, is less than 8,000 cfm (FA).

2). Unit is operating in cooling mode and control valve on cooling coil is open.

f. Interlock rotary air-to-air heat exchanger (heat wheel) with unit supply fan so that heat exchanger is enabled when unit supply and exhaust fans operates.

C. Safeties

1. High static pressure safety switches on supply and exhaust fan discharges and low static pressure safety switches on the suction side of isolation control dampers shall be directly wired through motor control circuit (VFD or bypass starter) to shut down unit immediately and close outdoor air damper, exhaust air damper and supply smoke damper to prevent over pressurizing or collapsing ductwork if control system fails. Status of each pressure switch shall be reported to BAS system. Pressure switch must be manually reset before air handling unit can be started. Initial setpoint for high static pressure switch is +6” w.c. Initial setpoint for low static pressure switch is -4” w.c.

2. Low temperature switch located at the leaving side of heat recovery coil shall be directly wired through motor control circuit to stop air handling unit and close outdoor air damper, exhaust air damper and supply smoke damper upon sensing air temperature below 38°F. Status of temperature switch shall be reported to BAS. Time delay relay shall be programmed between freezestat and controller to allow air handling unit outside air to stabilize upon startup to prevent spurious trips from occurring when outside air damper(s) opens and cold outside air enters the air handling unit. Temperature switch must be manually reset before air-handling unit can be started.

3. Heat recovery coil water valve shall partially open, 15% (FA), when low temperature switch is in alarm to provide additional coil freeze protection.

4. Supply air duct smoke detector in discharge air ductwork, located before discharge smoke damper, shall be wired to fire alarm system. BAS smoke damper control output shall be wired in series with a fire alarm system addressable relay contact so that either signal will cause the smoke dampers to close. Separate fire alarm control relays are to be provided for each AHU. Addressable fire alarm relay shall be directly wired through motor control circuit to stop respective air handling unit fans upon detection of smoke. Status of smoke detector shall be reported to BAS. Upon unit shutdown, outdoor, exhaust and supply smoke air dampers shall close.

5. System shall continue to operate when building fire alarm is active and supply and exhaust smoke detectors are not in alarm.

D. Supply and Exhaust Air Volume Control

1. Each air handling unit has a bank of multiple plenum type supply and exhaust fans installed in parallel in a common AHU partition wall (fan array). The fans are variable volume and the speed of the fans is controlled in unison through a single variable frequency drive.

2. Arrange VFD setting so fans will start on low speed. On failure of fan volume control signal, fans shall go to pre-programmed speed setting.

3. Pressure transmitters shall be mounted in supply and exhaust air ducts as shown on drawings.

4. Control supply fan VFD’s in unison to maintain supply duct static air pressure setpoint. Initial setpoint shall be 1.0" WG.

5. Control exhaust fan VFD's in unison to maintain exhaust duct static air pressure setpoint. Initial setpoint shall be -1.0" WG.
6. Control Contractor shall work in association with Test and Balance Contractor to determine actual required static pressure setpoints.
7. Each array fan is provided with a back-draft damper. Provide end switch at each damper to prove individual fan operation.

E. Fan discharge Damper Control:
1. Each supply and exhaust fan section has two position discharge air smoke/isolation dampers (FC). When closed, damper isolates air handling unit from supply/exhaust air distribution system.
2. Upon starting first air handling unit fully open fan AHU discharge damper upon signal for fans to start.
3. When starting second air handling unit while one air handling unit is already operating, discharge dampers of second unit shall remain closed until differential pressure across discharge dampers falls below .1 inches W.G. (FA). Then open discharge damper and control fan speeds of both units in unison.
4. Opening rate of fan discharge damper shall be coordinated with fan ramp speed to prevent backflow or stall of supply fan.
5. When associated supply/exhaust fan array is not operating associated damper shall be closed.

F. Air-to-Air Heat Exchanger (Heat Wheel) Control
1. Heat wheel is provided with factory packaged controls.
2. Controls contractor to interface with packaged wheel controls such that all analog and discrete input points, set point adjustments, and alarms are available via communication interface.
3. Heat wheel shall be enabled by the BAS to run when respective AHU is operational and proven operating by supply fan and exhaust fan run status.
4. System Operation
   a. Heat wheel shall have summer, winter and bypass modes of operation.
   b. Summer mode shall be determined any time the outside air temperature is above the exhaust air temperature and the exhaust air temperature is above the heating setpoint for 30 consecutive minutes (FA).
   c. Winter mode shall be determined any time the outside air temperature is less than supply air temperature setpoint for 30 consecutive minutes (FA).
   d. Bypass mode shall be determined any time the outside air temperature is between 52°F (FA) and 75°F (FA) for 30 consecutive minutes (FA).
5. Summer Mode
   a. Heat wheel shall operate at 100% speed (FA).
6. Winter Mode
   a. The heat wheel shall operate in two modes while in winter mode of operation.
      1). Frost control mode
      2). Supply temperature control mode.
   b. Supply air temperature control mode of operation shall be determined when the outside air temperature is less than 52°F (FA) and the exhaust air inlet (return air) temperature is greater than the condensation protection setpoint for 10 consecutive minutes (FA).
      1). Wheel speed shall be modulated to maintain the heat wheel leaving air temperature setpoint of 52°F (FA).
      2). Upon an increase of wheel leaving air temperature above setpoint, the wheel speed shall decrease to maintain the leaving air temperature setpoint.

3). Upon a decrease of wheel leaving air temperature below the setpoint, the wheel speed shall increase to maintain the leaving air temperature setpoint.

c. Frost control mode of operation shall override the supply air temperature mode of operation when the heat wheel is in winter mode and the exhaust air outlet temperature sensor is less than the frost setpoint of 32°F (FA).

1). The wheel speed shall be modulated to limit exhaust air RH to 93% (FA) when outside air temperature is below 35°F (FA). Wheel rotation will stop at 96% (FA) and resume normal discharge air temperature control for RH less than 90% (RH).

2). If outside air temperature entering the supply side of the total energy wheel falls to -5°F (FA) for more than 10 minutes (FA), wheel rotation shall stop. Resume normal discharge air temperature control when outside air temperature is above -5°F (FA) for more than 10 minutes.

7. Bypass Mode

a. BAS shall disable (stop) wheel and open supply and exhaust heat wheel bypass dampers.

G. Unit Discharge Supply Air Temperature Control

1. Modulate cooling coil control valve in sequence with heat recovery coil control valve to maintain supply air temperature of 52°F (FA).
2. The chilled water valve shall close whenever the unit is off.
3. The heat recovery water valve shall open to 15% (FA) whenever the unit is off and the outside air temperature is below 35°F for freeze protection of the heat exchanger.

H. Failure Modes

1. Fan failure alarm shall be annunciated at the workstation if the either the supply or exhaust fan does not start within 2 minutes as sensed by VFD, or duct static pressure.
2. Failure mode shall be initiated when unit is shutdown due to one of safety controls or from loss of signal.
3. Fans are served by standby power. On loss of power, shut down fans per stop sequence describe above. Units shall be automatically restarted per start sequence above after resumption of normal or standby power after power outage.
4. Control dampers shall move to their fail position when unit is off during failure mode.
5. Upon failure of end switch at any back-draft damper generate alarm to indicate fan failure. Alarm shall identify which system and which fan has failed.
6. On loss of supply duct static pressure signal, BAS controls shall maintain the last known fan speed.
7. Upon failure of one unit the other units supply and exhaust fans shall ramp to full speed. All air terminals not associated with the laboratory shall close. All air terminals shall return to normal operation upon return of normal power.

I. Humidity Control:

1. Primary humidifier shall be controlled as specified under primary humidifier control sequence.

J. Miscellaneous:

1. Provide safety low limit (freeze stat) control at leaving side of heat recovery heating coil. It shall de-energize unit supply fan, and close outside air dampers when low limit temperature is below 34°F.
2. Provide high static pressure limit control with sensor located in unit discharge to override fan volume control when pressure reaches 8 inches WG (FA).
3. Alarm:

a. Generate alarms as indicated:

1). Discharge air temperature

a). Generate alarm if temperature is more than ±4 °F (FA) from setpoint.

2). Supply fan backdraft damper position (closed) – each fan
   a). Generate alarm if damper is indicated closed.
3). Supply fan VFD failure
   a). Generate alarm if VFD failure is indicated.
4). Exhaust fan VFD failure
   a). Generate alarm if VFD failure is indicated.
5). Outside air damper position
   a). Generate alarm if damper is not proven open within 60 seconds (FA) of AHU start signal or not closed within 60 seconds (FA) of AHU stop signal.
6). AHU supply smoke/isolation damper position – each damper
   a). Generate alarm if damper is not proven open within 60 seconds (FA) of HAU start signal or closed within 60 seconds (FA) of AHU stop signal.
7). Fan discharge high static pressure switch wired to VFD safety circuit
   a). Stop fan(s) and generate alarm if pressure exceeds 7” WG.
8). Fan suction low static pressure switch wired to VFD safety circuit (each fan)
   a). Stop fan(s) and generate alarm if pressure less than -5” WG.
9). Freeze stat
   a). Generate alarm when upon sensing temperature below 38°F.

3.17 SMOKE/FIRE ALARM MODE - CONTROL SEQUENCE

A. Smoke Detectors in Ductwork:
   1. Smoke detectors will be furnished, installed, and wired to Fire Alarm Control Panel by Electrical Contractor.
   2. Wire contact on Fire Alarm System provided by EC to air handling unit supply and exhaust fan starter to shut down unit fans when Fire Alarm System is in alarm condition. Exhaust fans EF-3, EF-4 and EF-5 shall remain in operation.
   3. Smoke detectors will be provided for the following air handling units.
      a. AHU-1 and AHU-2
         1). Associated supply air ductwork
         2). Associated exhaust air ductwork

3.18 OXYGEN DEPLETION - CONTROL SEQUENCE

A. Controls contractor shall provide O2 sensors and transmitter and horn/strobe as indicated on plans.

B. Transmitter to automatically generate local alarm to horn/strobes when oxygen level is below 19.5% (FA).

C. When oxygen level is below 19.5% (FA) an alarm shall be sent to BAS and fire alarm system.

3.19 RADIO ISOTOPE EXHAUST FAN (EF-5) - CONTROL SEQUENCE

A. General:
   1. System consists of a single exhaust fan with VFD and shall operate continuously at constant volume.
   2. Exhaust fan is provided with air flow measuring device for use in controlling Building Pressure Control Exhaust Air Valve, EV-C102A (-D). Provide all fitting, tubing and transmitter required to monitor fan flow. Coordinate with fan supplier.
   3. System shall start/stop through BAS.
   4. Refer to drawing MI5.1.2

B. Constant Volume Control:
   1. Fume exhaust system shall be controlled to maintain duct system pressure as sensed by static pressure sensor/transmitter located in the fume exhaust system.

C. Failure Mode
   1. Fan failure alarm shall be annunciated at the workstation if the exhaust fan does not start within 2 minutes as sensed by VFD or duct static pressure.
   2. Failure mode shall be initiated when unit is shutdown due to one of safety controls or from loss of signal.
   3. Fan is served by standby power. On loss of power fan shall stop. Fan shall be automatically restarted per start sequence after resumption of normal or standby power.
   4. On loss of exhaust duct static pressure signal, BAS controls shall maintain the last known fan speed.

D. Exhaust fans shall be controlled with electrical interlock with air handling units. Refer to air handling unit control sequence for interlocking requirements.

E. Refer to the exhaust fan schedules for interlocking schedule.

3.20 FUME EXHAUST FANS (EF-3 AND EF-4) - CONTROL SEQUENCE

A. General:
   1. There are two fume exhaust fans. Both fans operate continuously at 50% of the total required exhaust air flow rate under normal operation at constant volume.
   2. Each exhaust fan is provided with air flow measuring device for use in controlling Building Pressure Control Exhaust Air Valve, EV-C102A (-D). Provide all fitting, tubing and transmitter required to monitor fan flow. Coordinate with fan supplier.
   3. System shall start/stop through BAS.
   4. Refer to drawing MI5.1.2

B. Exhaust Volume Control:

C. Fume exhaust system shall be controlled to maintain duct system pressure as sensed by static pressure sensor/transmitter located in the fume exhaust system.

D. Failure Mode
   1. Fan failure alarm shall be annunciated at the workstation if the either the exhaust fan does not start within 2 minutes as sensed by VFD, or duct static pressure.
   2. Failure mode shall be initiated when unit is shutdown due to one of safety controls or from loss of signal.
   3. Fans are served by standby power. On loss of power fans shall stop. Fans shall be automatically restarted per start sequence after resumption of normal or standby power after power outage.
   4. Isolation control dampers shall move to their fail position when unit is off during failure mode.
   5. On loss of exhaust duct static pressure signal, BAS controls shall maintain the last known fan speed.
   6. Upon failure of one exhaust fan the other exhaust fan shall ramp to maintain static pressure.

E. Isolation Damper Control:
   1. Each fume exhaust fan has its own individual automatic isolation damper.
   2. This damper shall be opened whenever associated fan is signaled to start, end switch shall energize associated exhaust fan and closed whenever fan is signaled to stop. Isolation damper shall close only after fan completely stops. Exhaust fan shall not start until its associated isolation damper is proven open by end switch.

F. Exhaust fans shall be controlled with electrical interlock with air handling units. Refer to air handling unit control sequence for interlocking requirements.

G. Refer to the exhaust fan schedules for interlocking schedule.

3.21 TORNADO SHELTER EXHAUST FAN (EF-6) - CONTROL SEQUENCE

A. System consists of a constant volume exhaust fan with electrically actuated isolation damper and intake air hood with electrically actuated damper dedicated to a single space.

B. System shall start/stop manually via local two-position selector switch. Two local control stations are to be provided. Refer to Mechanical plans for locations.

C. Exhaust fan shall be interlocked with both exhaust fan isolation damper and intake air hood damper so that fan will not be allowed to start unless both dampers indicate open via end switches. Damper end switches shall be hardwired to fan motor starter circuit.

D. Provide two local fan start/stop stations to include the following:
   1. Start/Stop selector switch – provide legend plate/label
   2. Fan “Running” Light (Red) – provide legend plate/label

E. Failure Modes
   1. Local controls are served by standby power.

3.22 SANITARY WASTE LIFT STATION MONITOR AND ALARM

A. Lift station has packaged operating and safety controls. Lift station unit is equipped with dry contract for high level alarm interface to BAS.

B. BAS shall annunciate an alarm at the workstation.
   1. Generate the alarms indicated:
      a. Pump high level alarm dry contract
      b. Common alarm

3.23 LABORATORY WASTE LIFT STATION MONITOR AND ALARM

A. Lift station has packaged operating and safety controls. Lift station unit is equipped with dry contract for high level alarm interface to BAS.

B. BAS shall annunciate an alarm at the workstation.
   1. Generate the alarms indicated:
      a. Pump high level alarm dry contract
      b. Common alarm

3.24 LABORATORY COMPRESSED AIR SYSTEM MONITORING AND ALARM

A. Compressed air system has packaged operating and safety controls. Laboratory compressed air system is equipped with dry contract for high level alarm interface to BAS.

B. BAS shall annunciate an alarm at the workstation.
   1. Generate the alarms indicated:
      a. Compressed air run status
      b. Common compressor and air drier alarm

3.25 ELECTRICAL SYSTEMS MONITORING

A. Transfer switches are equipped with dry contact controlled by position of transfer switch for use by BAS. Control Contractor is responsible for wiring dry contact from transfer switches to BAS.

B. BAS shall monitor position of each transfer switch.
   1. Generate alarm when transfer switches change from “normal power” position to “standby power” position and utilize for initiating standby power control sequences.

3.26 STANDBY POWER OPERATION:

A. Upon loss of offsite power, hardwired loss of power signals from 480V automatic transfer switch will be used to automatically start 480 V standby generator. Loss of power signal is also input to BAS.

B. BAS, upon loss of off-site power, will inhibit all major loads which are backed up by standby diesel generator from restarting upon availability of standby power. Upon verification of adequate and sufficient bus voltage, and automatic transfer switch is in "Emergency Power" position, BAS shall reclose "START/INHIBIT" contacts, in predetermined sequence, for critical loads on standby bus.

C. All air handling units, all exhaust fans, all environment room systems, and all pumps are powered from standby power bus. This equipment will function during loss of normal power.

D. Mechanical systems shall restart automatically in the following order. BAS controls panels served by standby power shall be energized first. Time interval between starts shall be 10 seconds (FA):

First:	HWP-1or HWP-2
Second:	HWP-3 or HWP-4
Third:	EF-3 or EF-4
Fourth:	EF-5
Fifth:	AHU-1 (SF-1 and EF-1) or AHU-2 (SF-1 and EF-2)
Sixth:	CHP-1 or CHP-2
Seventh:	Environmental Room Coolers, Dehumidifiers and Pumps. DX Unit coolers shall be enabled to start according to their normal operating sequence.

E. Return to Normal Power Operation:
   1. Once normal power is restored, switch over will be accomplished as described in loss of power.
   2. All equipment operating on standby power shall stop operating before restarting.

End of Section

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SECTION 23 21 16

PIPE AND PIPE FITTINGS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 05 29 - Mechanical Supporting Devices

B. Section 22 15 00 - Industrial Compressed Air System

C. Section 22 16 00 - Natural Gas Piping

D. Section 23 05 94 - Water Systems Test Adjust Balance

E. Section 23 09 02 - Control Valves and Damper (Valves)

F. Section 23 09 03 - Control Instrumentation (Wells, Taps or In-line Devices)

G. Section 23 21 18 - Valves

H. Section 23 21 20 - Piping Specialties

I. Section 23 25 14 - Chemical Treatment Systems (Pipe Cleaning)

J. Section 26 32 13 - Engine Generators

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. This Section includes pipe and pipe fitting specifications and installation requirements for heating and cooling systems.

B. Specification of an item in this or any other sections shall not relieve Contractor from providing all items, articles, materials, operations, methods, labor, equipment and incidentals necessary for a complete and functional system.

C. Use only new material, free of defects, rust and scale, and guarantee for services intended.

D. Use material meeting the latest revision of ASTM specifications as listed in this specification.

E. Follow local codes if they require other types of pipe or joints.

F. Use only long radius elbows having centerline radius of 1.5 pipe diameters unless otherwise indicated.

G. Manufacturer, pressure class, size and heat code of each fitting and flange shall be permanently identified on its body in accordance with MSS SP-25.

H. Where size for a pipe segment is not indicated, the pipe segment size shall be equal to the largest pipe segment to which it is connected. Transition to smaller size shall occur on the side of fitting where smaller size is indicated.

I. Unless otherwise indicated, fittings and accessories connected to pipe shall be of the same material as the pipe.

J. Unless otherwise indicated, construct piping for highest pressures and temperatures in respective system in accordance with the latest revision of the applicable Sections of ASME Code for pressure piping, ASME B31 including the following:
   1. B31.9 Building Services Piping
   2. B31.5 Refrigeration Piping

K. Non-metallic piping is acceptable only for services indicated. It is not acceptable in occupied spaces and ventilation plenum spaces.

1.4 SUBMITTALS

A. Shop Drawings for each piping system for all pipe sizes including, but not limited to, the following:
   1. Name of system
   2. Pipe; ASTM number, grade if known, type, wall thickness, material
   3. Fittings; ASME number, grade if known, class, type, wall thickness, material
   4. Joint type
   5. Flanges; ASTM number, grade, class, type, material
   6. Bolts and nuts; material
   7. Thread joint sealants; material
   8. Flange gaskets; material, rating
   9. Unions; ASTM number, type, material, rating
   10. Type of welding
   11. Welding Quality Control Program
   12. Test pressure and media
   13. Pipe flushing/cleaning plan
   14. Pipe cleaning method
   15. All other appropriate data

B. Submit pipe certification as specified under Pipe Certification in this Section.

C. Submit required documents as specified under Pipe Welding in this Section.

D. Coordinated shop drawings.

E. Provide Flushing and Cleaning Plan:
   1. Submit pipe flushing/cleaning plan for water, fluid, steam and condensate systems for approval. Plan shall detail methods for compliance with requirements of this section, including:
      a. Size, power source, and connection points of contractor provided pumps that will be used for flushing and cleaning.
      b. Calculations, along with drawings or diagrams showing, sectioning or zoning of piping systems to achieve required velocities, location and means of temporary bypasses and returns.
      c. Flushing schedule and drawings or diagrams that will be used for inspection and sign off prior to and after procedure, at Laboratory's option.
   2. Submit documents showing verification of flashing/cleaning following specified requirements and results.

F. LEED Submittal

1. Product Data for IEQ Credit 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Furnish pipe with plastic end-caps/plugs on each end of pipe. Maintain end-caps/plugs through shipping, storage and handling to prevent pipe-end damage and eliminate dirt and construction debris from accumulating inside of pipe.

B. Where possible, store materials inside and protect from weather. Where necessary to store outside, elevate well above grade and enclose with durable, waterproof wrapping.

C. Before shipping, all carbon steel piping shall be free of rust and scale, and furnished with plastic end caps/plugs on each end of pipe.

1.6 PIPE WELDING

A. Procedure and Welding Qualification Records:

1. Submit Welding Procedure Specifications (WPSs) and their supporting Procedure Qualification Records (PQRs) to be used on the work to Engineer for review and approval prior to performing any welding. These documents shall meet requirements of ASME B31.1 and B31.9, as applicable.
2. Unless otherwise indicated, welding shall be done using only the following processes:
   a. Shielded Metal Arc Welding (SMAW), also known as "stick" welding
   b. Gas Tungsten Arc Welding (GTAW), also known as TIG and Heliarc welding
   c. Gas Metal Arc Welding (GMAW), also known as MIG welding
   d. Flux-Cored Arc Welding (FCAW), a variation of GMAW
   e. Submerged Arc Welding (SAW)
3. Root pass must be applied by only GTAW process with argon gas purge for stainless steel pipe.
4. Unless otherwise stated, fabrication, installation, inspection, examination and testing shall be in accordance with ASME B31.1.
5. Backing rings (chill rings) or consumable inserts are not allowed, unless specifically requested by Laboratory or Engineer.

B. Weld Inspection and Examination:

1. Provide examination services for all welding for this Project. Examination shall be in accordance with requirements of ASME B31.1, Table 136.4 as applicable. Personnel performing examinations shall comply with requirements stipulated in 136.1 (A) through (E) or shall be AWS QC1 Certified.
2. Periodically, as welding progresses, submit report, signed by weld examiner, indicating status of project welding quality.
3. Arrange with Laboratory's Inspector for observation of fitup and welding methods prior to implementing any welds, including shop welds, on this Project.
4. In addition, Laboratory's Inspector will perform any additional observations deemed necessary before, during, or after fabrication to assure, to Laboratory's satisfaction, that proper welding is provided. Laboratory reserves the right to perform independent examination of welds. If Laboratory has any concern as a result of such examination Laboratory reserves the right to stop in progress welding work, without any cost to Laboratory, until resolution satisfactory to Laboratory is reached.

C. Welder Qualifications:
   1. Each welder and welding operator must qualify by passing required procedure test before performing any project welds. Submit copy of Manufacturer's Record of Welder or Welding Operator Qualification Tests (WPQS) as required by Section IX of ASME Boiler and Pressure Vessel Code for all welding procedures to be performed by welding operator.
   2. Welder qualifications must be current. If qualification test is more than 6 months old, provide record of welding continuity for each welder.
   3. Record of welding continuity is intended to show that welder has performed welding at least every 6 months since the date that welder qualification test was passed for the submitted welding procedure specification.
   4. Record of welding continuity shall include, at minimum, the following:
      a. Welder's employer name and address
      b. Date Welder Qualification Test was passed
      c. Dates indicating welding continuity
   5. Welders shall be qualified as required by ASME B31.1, as applicable. In addition, there shall be an independent witness of welder tests. That witness shall be representative of independent testing laboratory, Authorized (Code) Inspector, Laboratory's or Engineer's Inspector or consultant approved by National Certified Pipe Welding Bureau.
   6. Welder qualifications must cover all pipe sizes and wall thickness used on this project. Test segments or coupons shall be appropriately selected for qualification. Test position shall be arranged in "6G position."

PART 2 - PRODUCTS

2.1 HEATING HOT WATER AND HEAT RECOVERY

A. 2" and Smaller:
   1. Pipe: ASTM B88 seamless, Type L, hard temper copper tube
   2. Fittings: ASME B16.22, wrought copper solder joint
   3. Joint: ASTM B32, lead free solder, Bridgit, Silvabrite, Silverflow or Canfield
   4. Unions: ASME B16.18 cast copper alloy or ASME B16.22 wrought copper solder joint, Class 125
   5. Flanges: ASME B16.24, Class 150, cast copper alloy
   6. Use solder joints for valves and piping specialties in copper piping
   7. Press Joint Option:
      a. Contractor may use press copper fittings as manufactured by Viega. Other acceptable manufacturers are Nibco, ProPress and Elkhart.
      b. Fittings: Copper press fittings with EPDM seal, 0 to 250°F, maximum 200 psi.
      c. Joints: Press joints by fitting manufacturer approved tool.

B. 2-1/2” and Larger:
   1. Pipe: ASTM A53, Grade B, Type E or S, standard weight, carbon steel
   2. Fittings: ASTM A234 Grade WPB/ASME B16.9, standard weight, seamless, carbon steel weld
   3. Flanges: Class 150. Refer to Unions and Flanges in this Section
   4. Press Joint Option:
      a. Contractor may use press copper fittings as manufactured by Viega. Other acceptable manufacturers are Nibco, ProPress and Elkhart.
      b. Pipe: ASTM B88 seamless, Type L, hard temper copper tube

c. Fittings: Copper press fittings with EPDM seal, 0 to 250°F, maximum 200 psi.

d. Joints: Press joints by fitting manufacturer approved tool.

2.2 CHILLED WATER

A. 2" and Smaller:

1. Pipe: ASTM B88 seamless, Type L, hard temper copper tube
2. Fittings: ASME B16.22, wrought copper solder joint
3. Joint: ASTM B32, lead free solder, Bridgit, Silvabrite, Silverflow or Canfield
4. Unions: ASME B16.18 cast copper alloy or ASME B16.22 wrought copper solder joint, Class 125. No unions to be used for lines sizes 3/4" and smaller. Unions shall be used for line sizes over 1".
5. Flanges: ASME B16.24, Class 150, cast copper alloy
6. Use solder joints for valves and piping specialties in copper piping.
7. Press Joint Option:
   a. Contractor may use press copper fittings as manufactured by Viega. Other acceptable manufacturers are Nibco and Elkhart.
   b. Fittings: Copper press fittings with EPDM seal, 0 to 250°F, maximum 200 psi.
   c. Joints: Press joints by fitting manufacturer approved tool.
8. Mechanical coupling option:
   a. Contractor may use mechanical coupling as outlined in section 1.9.

B. 2-1/2" through 6":

1. Pipe: ASTM A53, Grade B, Type E or S, standard weight, carbon steel
2. Fittings: ASTM A234 Grade WPB/ASME B16.9, standard weight, seamless, carbon steel weld
3. Flanges: Class 150. Refer to Unions and Flanges in this Section
4. Press Joint Option (2-1/2” through 4”):
   a. Contractor may use press copper fittings as manufactured by Viega. Other acceptable manufacturers are Nibco and Elkhart.
   b. Fittings: Copper press fittings with EPDM seal, 0 to 250°F, maximum 200 psi.
   c. Joints: Press joints by fitting manufacturer approved tool.
5. Mechanical coupling option:
   a. Contractor may use mechanical coupling as outlined in section 1.9.

2.3 STAINLESS STEEL PIPING 304L

A. 2" and Smaller:

1. Pipe: ASTM A312, 304L, Schedule 10S, seamless stainless steel
2. Fittings: ASTM 182, Gr. F304, ASME B16.11, 3000 lb socket-weld
3. Unions: 3000 lb socket-weld, stainless steel ground joint

B. 2-1/2” and Larger:

1. Pipe: ASTM A312, 304L, Schedule 10S, seamless stainless steel
2. Fittings: ASTM A403, Gr. WP, Class S or Class W, ASME 16.9
3. Flanges: ASTM A182, Gr. F304, ASME B16.5, 150 lb std. with 1/16" raised face, serrated face finish and welding neck
4. Bolts: Stud bolts, ASTM A193, Gr. B7
5. Nuts: ASTM A194, Gr. 2H

C. Acceptable mechanical coupling manufacturers include, but shall not be limited to, Victaulic, Grinnell and Gustin and Bacon. Manufacturer shall have had at least 10 years of experience with similar couplings to those provided. They shall be malleable iron and shall conform to ASTM A 53, Type E for sizes 3/4 through 30 inches.

D. At the Contractors option mechanical grooved or rolled end couplings, and fittings and pipe specialty items such as tees, elbows, etc., but not including valves, strainers, flange adaptors, and other piping accessories may be used within the manufacturer's recommended temperature range. The Contractor shall have at least five years of successful installation experience with mechanical couplings:

1. DI (Process) Water in conjunction with stainless steel piping.

E. Couplings shall be rigid type equivalent to Victaulic "Style 07" except for the first three connections to and from pumps and chillers where "Victaulic Type 77" shall be considered, per the manufacturer's recommendations.

F. Gaskets shall be of EPDM rubber specially prepared for and compatible with the intended service and shall be suitable for temperature from 30˚F to 230˚F.

G. Fittings shall be full flow conforming to ASTM A 47 and ASTM A 536. Where malleable iron/ductile iron fitting patterns are not available standard wall seamless welded fittings with grooved ends may be used.

H. Tools utilized for rolling or grooving shall be approved by the manufacturer of the couplings.

I. Couplings and their assembly shall be able to withstand the system test pressure indicated in the system description sections.

2.4 RAW WATER MAKE-UP

A. Refer to Section 22 1118 - Water Distribution System

2.5 CHEMICAL TREATMENT

A. Closed Water System (Hot Water, Chilled Water, Heat Recovery Water, etc.):

1. Use pipe and fittings as indicated for the system to which chemical treatment piping is connected.

2.6 VENTS AND RELIEF VALVES

A. Use pipe and pipe fittings as indicated for the system to which relief valve or vent is connected.

2.7 PRESSURE GAUGES AND TAPPINGS

A. Use pipe and pipe fittings as indicated for the system to which pressure gauge or tapping is connected. Use "Threadolets", "Sockolets" or tee fittings for tappings. Refer to Part 3 under General for use of "Threadolets" and "Sockolets".

B. Gauge pipe shall be 1/4" unless otherwise indicated.

2.8 COOLING COIL CONDENSATE DRAIN

A. Piping shall be one of the following, unless otherwise indicated on drawings:

1. Pipe: ASTM A53, Type F, standard weight, galvanized steel
2. Fittings: ASTM A126/ASME B16.4, cast iron, threaded, ASTM A123 galvanize coated
3. Pipe: ASTM B88, Type M, hard temper copper tubing
4. Fittings: ASTM B16.22 wrought copper fittings

5. Joint: ASTM B32, 95-5 tin-antimony solder, Bridgit or Silvabrite
6. Pipe: ASTM D1785, Schedule 40, polyvinyl chloride (PVC)
7. Fittings: ASTM D2665, solvent weld PVC fittings

2.9 DIELECTRIC UNIONS, FLANGES AND FITTINGS

A. Copper to Steel Pipe:
1. 2" and Smaller: Use ball valves specified in Section 23 2118 for dielectric purpose.
2. ASTM A197/ASME B16, equal to Stockham Figure 693-1/2, Watts Series 3000 or Wilkins (Zurn) Model DU series dielectric unions with EPDM dielectric gasket, 250 psi at 180°F.
3. Clearflow Dielectric Waterway fittings (Victaulic Style 47) may be used in lieu of dielectric unions for pipe sizes 2" and smaller.
   a. Clearflow fittings shall be ASTM A53 electro zinc-plated steel pipe with high temperature polyolefin polymer liner, suitable for continuous use at temperatures up to 230°F and pressures up to 300 psig.
4. 2-1/2”and Larger: Watts dielectric flange fittings Series 3100/3110 with dielectric gasket, 175 psi at 210°F.

B. Steel to Steel Pipe:
1. 1" and Smaller: Similar to Epco model HA-B with dielectric gasket, 250 psi at 210°F
2. 1-1/2" and Larger: Similar to Epco model W with bolt insulators, dielectric gasket, bolts and nuts, 175 psi at 210°F). Pikotek model VSC dielectric gasket with viton sealing element, G-10 sleeve and double washers, suitable to 350°F, may be used with specified flanges.

2.10 UNIONS AND FLANGES

A. Unions:
1. 2" and Smaller: Malleable iron, ASME B16.39 with ground joint, bronze or brass to iron. Provide black malleable iron for carbon steel piping and galvanized malleable iron for galvanized steel piping. Unless otherwise specified, pressure class and joint type of union shall be equal to that specified for fittings of respective piping service. Minimum pressure class of unions shall be Class 250.

B. Flanges:
1. 2-1/2” and Larger: ASTM A105, ASME B16.5, hot forged steel, welding neck pattern. Slip-on pattern are not allowed. Bore dimension of welding neck flange shall match inside diameter of connected pipe.
2. Use raised face flanges for mating with other raised face flanges with self-centering flat ring gaskets. Use flat face flanges for mating with other flat face flanges with full face gaskets.
3. Flange pressure class indicated in respective piping service is minimum required. Mating flange pressure class shall match pressure class of connected device, such as valves and piping specialties.

C. Flange Gaskets:
1. General - Gasket material shall be asbestos free and suitable for pressures, temperatures and fluid of respective piping system. Non-metallic gaskets shall be in accordance with ASME B16.21 and ASTM F104.
2. Service Temperature (through 249°F) – Garlock, Klingersil or J.M. Clipper, similar to Garlock 5500. Gaskets similar to Garlock Style 3000 may be used for hydronic piping. Unless otherwise indicated or recommended by manufacturer, gaskets shall be compressed inorganic fiber with nitrile binder 1/16" thick for flanges 12" and smaller and 1/8” thick for flanges 14” and larger.

D. Bolting:
1. Bolts, bolt studs, nuts and washers shall have zinc plated finish.

2. Thread shall be in accordance with ASME B1.1, Class 2A tolerance for external threads and Class 2B tolerance for internal threads. Threads shall be coarse-thread series except that alloy steel bolting 1/8" and larger in diameter shall be 8 pitch thread series.
3. Threaded rods are not allowed as fastening elements.
4. For Class 150 and Class 300 flanges not exceeding 400°F temperature, use carbon steel bolts or stud bolts conforming to ASTM A307, Grade B with nuts conforming to ASTM A194.
   a. Bolts conforming to ASTM A307, Grade A may be used for piping governed by ASME B31.9.
5. For Class 400 and 600 flanges at 750°F or lower temperature, use alloy steel bolts or stud bolts conforming to ASTM A193, Grade B7 or B16, with nuts conforming to ASTM A194, Grade 2H.

2.11 THREADED JOINT SEALANTS

A. Paste type for brush application or cord type. Products shall be non-toxic, chemically inert, non-hardening, rated for -50°F to 400°F and up to 10,000 psi (liquids) and 3000 psi (gases), certified by UL, CSA, and NSF.

B. Use sealant similar to Loctite Model 54531 for piping handling oil or petroleum products.

2.12 WELD BRANCH OUTLET FITTINGS (WELDOLETS, THREADOLETS AND SOCKOLETS)

A. Weld branch outlet fittings shall conform to MSS-SP-97, ASME B16.9 for weldolets, ASME B1.20.1 for threadolets and ASME B16.11 for sockolets.

B. Materials shall match material of header piping and wall thickness of outlet or branch end shall match wall thickness of branch pipe.

2.13 MECHANICAL GROOVED PIPE CONNECTIONS

A. Mechanical grooved pipe coupling system including elbow, tee and reducer fittings, as manufactured by Victaulic, Tyco Grinnell or Anvil Gruvlok may be used in lieu of flanged or welded steel piping 2-1/2" and larger for systems indicated below.

B. Grooved pipe connection system materials used for the Project shall be produced by the same manufacturer.

C. Couplings shall be equal to Victaulic 07 or 107 ridged couplings. However, three (3) Victaulic 77 or 177 flexible couplings in close proximity to pump connection (except in-line pumps) may be used in lieu of flexible connectors required in Section 23 0550 - Vibration Isolation.

D. Victaulic Style 107 QuickVic rigid couplings with EHP gaskets may be used.

E. Grooved fittings, valves, and specialties manufactured by coupling manufacturer will be acceptable, provided it meets requirements specified in this Section.

F. The following services may use mechanical grooved pipe connections within mechanical equipment spaces. Mechanical grooved pipe connections shall not be used in or above occupied spaces.
   1. Chilled Water
   2. Cooling Coil Condensate Drain

G. Acceptable materials are listed below, based on Victaulic. When used on galvanized piping, fittings and couplings shall be galvanized in accordance with ASTM A153 Hot Dip Galvanizing. When used on black steel piping, fittings and couplings shall have enamel coating. Fittings and couplings must be suitable for temperature and pressure involved.

H. Couplings:

1. Ductile iron, ASTM A-536, Grade 65-45-12, Style 07 or 107 Zero-flex rigid couplings, complete with housings cast with offsetting, angle-pattern bolt pads, used to provide system rigidity and support and hanging in accordance with ASME B31.1.
2. Ductile iron, Style 77 flexible couplings for use in locations where flexible connectors are required.

I. Flanges:
1. Ductile iron Style 741 or 743.

J. Fittings:
1. Ductile iron elbows and tees of manufacturer's standard line may be used in all sizes except bullhead tees will not be accepted. Fittings shall be full-flow fittings. Mechanical tee Style 920 or 920N fittings with ductile iron housings may be used for up to 4" outlet size.
2. Ductile iron fittings shall conform to ASTM A-536.

K. Gaskets:
1. Grade "E" EPDM compound, ASTM D-2000, suitable for temperature from -30°F to 230°F.

L. Bolts and Nuts:
1. Heat treated carbon steel, track head conforming to ASTM A-183 zinc electroplated, minimum tensile 110,000 psi zinc electroplated.

M. Expansion Joints:
1. Credit for inherent flexibility of mechanical grooved pipe connections when used for expansion joints, may be allowed upon specific application by Contractor. Request shall be made in writing and shall include service, location, line size, proposed application and supporting calculations for intended service.

2.14 REFRIGERANT PIPING

A. ASTM B88 Type L hard drawn copper tube, cleaned and capped in accordance with ASTM B280, and marked "ACR" with ANSI B16.22 wrought copper or forged brass solder-type fittings.

PART 3 - EXECUTION

3.1 GENERAL

A. Remove foreign materials before erection. Ream ends of piping to remove burrs.

B. Install piping parallel to building walls and ceilings and at such heights so as not to obstruct any portion of window, doorway, stairway, or passageway. Install piping to allow adequate service space for equipment. Refer to drawings and/or manufacturer's recommendations. Install vertical piping plumb. Where interferences develop in field, offset or reroute piping as required to clear such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings or other Architectural details before installing piping.

C. Provide anchors, expansion joints, swing joints and expansion loops so that piping may expand and contract without damage to itself, equipment or building.

D. Mitered elbows, welded branch connections, notched tees and "orange peel" reducers are not allowed. Unless specifically indicated, reducing flanges and reducing bushings are not allowed. Reducing bushings may be used for air vents and instrumentation connections.

E. Unless otherwise indicated, use fittings as specified in Part 2 of this Section for elbows, tees, reducers, etc.

F. "Weldolets" with outlet size 2-1/2" and larger and "Threadolets" or "Sockolets" with outlet size 2" and smaller may be used for branch connections up to one pipe size smaller than main. Use "Threadolets" where threaded fittings are specified and use "Sockolets" where socket weld fittings are specified. Install in accordance with PFI (Pipe Fabrication Institute) Standard ES49.

G. Install drains throughout systems to permit complete drainage of entire system.

H. Do not install piping over electrical panelboards, switchgear, switchboards or motor control centers.

I. Install valves, control valves and piping specialties, including items furnished by others, as specified and/or detailed. Provide reducing fittings for valves smaller than pipe size.

J. Make connections to all equipment installed by others where that equipment requires piping services indicated in this Section.

3.2 THREADED PIPE JOINTS

A. Threads of pipe and fittings shall conform to ASME B1.20.1.

B. Ream pipe ends after cutting and clean before erection. Apply thread sealants to cleaned male threads. Assemble joint to appropriate depth and remove any excess pipe joint compound from tightened joint.

3.3 FLANGED JOINTS

A. Clean flange surfaces and align them parallel. Bolt holes of gaskets shall be cut slightly larger than bolt diameter. Gasket ID shall be slightly larger than flange ID.

B. Position gasket concentrically so compression is equally distributed over entire gasket surface.

C. Lubricate bolts and run nuts down by hand.

D. By using torque wrench, tighten nuts in the proper sequence so gasket is compressed evenly, and to the appropriate torque specified by bolt manufacturer.

E. Re-torque bolts 12 to 24 h after start up.

3.4 WELDED PIPE JOINTS

A. Inspect pipe and pipe fittings for roundness before they are fit-up or set in place.

B. Properly clean and prepare pipe base material before fit-up. Verify joint land and bevel.

C. Preheat pipe base material as required by welding procedure specification. Temperature of pipe material must be minimum of 32°F before welding.

D. Properly align and adjust joint as required by welding procedure and thickness of material. Verify tolerances after tacking sequence.

E. Use weld material diameter as procedurally required for type and thickness of work being done.

F. Use sufficient argon pre-purge and argon post-purge for GTAW processes. Post purge should be until weld is no longer glowing plus 5 seconds. Maintain purge for at least 2 layers of weld material.

G. Properly store welding materials.

H. Clean tacks before welding out. Remove slag after each pass by grinding to avoid slag inclusion.

I. Weld reinforcement shall not exceed limits established in Chapter V of ASME B31.1.

J. Brush each weld free of rust and paint with rust resistant product that matches piping surface color.

K. For piping within scope of ASME B31.1, each weld shall be permanently marked by welder performing weld. Each welder shall sign and date field welding log record for all welds performed by welder as indicated in Part 1.

L. Conduct radiographic test for sections or joints that cannot be tested by hydrostatic test methods (such as joints cut into existing piping systems) by qualified radiographic testing firm.

3.5 COPPER PIPE JOINTS

A. Cutting of tubing shall not make tubing out of round. Ream cut tube ends to full inside diameter.

B. Remove slivers and burrs remaining from tube cut by reaming and filing both pipe surfaces. Clean fitting and tube with emery or sand cloth. Remove residue from cleaning operation, apply flux and assemble joint. Use solder or brazing to secure joint as specified for specific piping service.

C. Press Joint Option:
   1. Cut pipe square and ream before assembly
   2. Insert pipe fully into fitting and mark on pipe at shoulder of fitting
   3. Check fitting alignment against mark on pipe to ensure pipe is fully engaged
   4. Press joint with press tool approved by fitting manufacturer

3.6 PLASTIC PIPE JOINTS

A. Use cleaning procedure and solvent cement as recommended by pipe and fitting manufacturers for particular material being used.

3.7 POLYVINYL CHLORIDE (PVC) PIPING

A. Install PVC piping in strict accordance with pipe and fitting manufacturer's recommendations, including support spacing, compensation for thermal expansion and contraction and solvent cementing.

3.8 STEAM AND STEAM CONDENSATE

A. Pitch steam mains down at 1" per 40 ft in direction of flow. Pitch runouts to terminal equipment and control valves at 1/2" per 1 ft for proper condensate drainage. Install drip traps at each rise and at horizontal termination of each steam main.

B. Pitch steam condensate lines down at 1" per 20 ft in direction of flow.

C. Unless otherwise indicated, use eccentric fittings for changes in horizontal pipe sizes with fittings installed for proper condensate drainage (bottom of pipe straight). Concentric fittings may be used for changes in vertical pipe sizes.

D. For steam branch connections and runouts, use top or top 45° connection to main.

E. For condensate branch connections to condensate mains, use top or top 45° connection to main.

F. For condensate connections from steam mains, use bottom connection to main.

G. Install minimum of 3 elbows in each pipe runout to terminal equipment to provide flexibility for expansion and contraction of piping system.

3.9 WATER SYSTEMS

A. Pitch horizontal mains up at 1" per 40 ft in direction of flow. Install manual air vents at all high points where air may collect. If vent is not in accessible location, extend air vent piping to nearest code acceptable drain location with vent valve located at nearest accessible location to pipe.

B. Main branches and runouts to terminal equipment may be made at top, side or bottom of main provided that there are drain valves suitably located for complete system drainage and manual air vents are located as described above.

C. Unless otherwise indicated, for upfeed risers, use top or top 45° connection to main and for downfeed risers use side or bottom 45° connection to main. If side or bottom 45° connection is not practical and bottom connection to main must be used, provide line size Y strainer with shut-off valve at each side at branch connection.

D. Use minimum of 3 elbows in each pipeline to terminal equipment to provide flexibility for expansion and contraction of piping systems.

E. Use eccentric fittings for changes in pipe sizes and for valves smaller than pipe sizes, in horizontal lines, with fittings installed for proper air venting (top of pipe straight). Concentric fittings may be used for changes in pipe sizes and for valves smaller than pipe sizes in vertical lines.

F. Where mechanically formed tee fittings are allowed, form mechanically extracted collars in continuous operation, consisting of drilling pilot hole and drawing out tube surface to form collar having height of not less than 3 times thickness of tube wall. Collaring device to be adjustable.

G. Notch and dimple branch tubes. Braze joints. Apply heat properly so that pipe and tee do not distort. Remove distorted connections.

3.10 RAW WATER MAKE-UP

A. Refer to Section 22 1118 - Water Distribution System

B. Install piping where indicated, including valves, piping specialties and dielectric unions required for functional system.

C. Raw water make-up piping for this Section is defined as fill line containing pressure reducing valve for water systems.

3.11 CHEMICAL TREATMENT

A. Install piping as indicated on drawings, as detailed, and as recommended by supplier of chemical treatment equipment.

3.12 VENTS AND RELIEF VALVES

A. Install vent and relief valve discharge lines as indicated on drawings, as detailed, and as specified for each specific valve or piping specialty item.

3.13 COOLING COIL CONDENSATE DRAIN

A. Trap each cooling coil drain pan connection with trap seal of sufficient depth to prevent conditioned air from moving through piping. Extend drain piping to nearest code approved drain location. Construct trap with plugged tee for cleanout purposes.

B. Pitch pipe down at 1/4" per one foot for proper drainage.

C. Where copper piping is allowed, joints and fittings may be secured with 95-5 tin-antimony solder or brazing alloys.

3.14 DIELECTRIC UNIONS AND FITTINGS

A. Install dielectric unions, flanges or fittings in main and branch piping of water systems at each point where copper to steel pipe connection occurs. Dielectric unions or fittings shall not be used at terminal device connections.

B. Concealed dielectric unions and fittings are not allowed.

3.15 UNIONS AND FLANGES

A. Install union or flange at each automatic control valve and at each piping specialty or piece of equipment that requires tube pull or removal for maintenance, repair or replacement. If required, provide additional unions or flanges in order to facilitate removal of piping sections that interfere with tube pulls or equipment removal. Where valve is located at piece of equipment, provide flange or union connection on equipment side of valve.

B. Concealed unions or flanges are not allowed.

3.16 MECHANICAL GROOVED PIPE CONNECTIONS

A. Use pipe factory grooved in accordance with coupling manufacturer's specifications or field grooved pipe in accordance with the same specifications using specially designed tools available for application.

B. Grooved couplings, gaskets, fittings, valves, specialties, and grooving tools shall be provided from the same manufacturer.

C. Grooving shall be performed by qualified grooving operators having demonstrated proper grooving procedure in accordance with manufacturer's recommendations.

D. Lubricate pipe and coupling gasket, align pipe and secure joint in accordance with coupling manufacturer's specifications.

E. Support pipe as indicated in Mechanical Supporting Devices section of these specifications except as modified below. Support each horizontal pipe section at least once between couplings and whenever change in flow direction takes place. Support vertical pipe at every other floor or every other pipe length, whichever is most frequent. Set base of riser or base fitting on pedestal or foundation.

F. Follow coupling manufacturer's installation recommendations if they are more stringent than above requirements.

G. Factory trained field representative from grooved coupling manufacturer shall conduct on-site training for Contractor's field personnel in installation of grooved products and proper use of grooved tools. Grooved manufacturer's representative shall submit written documentation to verify completion of required training.

H. Factory-trained representative shall periodically visit jobsite after initial tool and installation training to review field grooving procedures and product installation to insure installation guidelines are being followed.

I. Contractor shall remove and replace any improperly installed products.

J. Factory-trained field representative shall provide additional training to Contractor to mitigate any further improperly installed products.

3.17 REFRIGERANT PIPING

A. Solder joints shall be ASTM Grade 4 or 5 and have melting point of approximately 1250°F. Solder impurities shall not exceed 0.15%. Tubing shall be new and delivered to job site with original mill end caps in place. Clean and polish joints before soldering. Avoid prolonged heating and burning during soldering. Purge pipes with nitrogen during soldering. Provide manual shut-off and check valves as required.

B. Leak test by charging system to pressure of 10 psig with the same type of refrigerant that will be used in the system.

C. Charge refrigerant into system through Sporlan catchall filter-drier. Finally increase pressure to 300 psig with oil pumped dry nitrogen. Rap joints with rubber or rawhide mallet and check for leaks with electric leak detector having certified sensitivity of at least one ounce per year. Seal any leaks that may be found and retest.

D. After completion of leak test, evacuate system with vacuum pump to 2.5 mm Hg absolute as measured on accurate gauge.

E. System ambient temperature shall be above 60°F during evacuation, charge refrigerant into system to 0 psig, then repeat evacuation to 2.5 mm Hg absolute. Allow system to stand evacuated for at least 12 h. If no noticeable rise in pressure occurs, system may be charged.

F. Charge system with new refrigerant through charging valve and filter-drier. Continue charging until bubbles disappear from liquid line sight glass while compressor is in operation.

G. Refrigeration piping must be installed by firms who are experienced in installation of such piping.

3.18 PIPING SYSTEM PRESSURE TESTS

A. Laboratory and/or Laboratory's representative may elect to witness pressure test. Notify Laboratory and/or Laboratory's representative at least 3 days in advance.

B. Conduct pressure test prior to flushing and cleaning of piping systems.

C. Conduct hydrostatic (HYDRO) test in accordance with ASME B31.1 137.4. Test pressure shall be in accordance with ASME B31.1, but shall not be lower than the minimum test pressure listed below.

D. If leaks are found, repair with new materials and repeat test until leaks are eliminated. Caulking will not be acceptable.

E. Pressure tests may be made of isolated portions of piping systems to facilitate general progress of installation. Any revisions made in piping systems require retesting of affected portions of piping systems.

F. No systems shall be insulated until it has been successfully tested. If required for additional pressure load under test, provide temporary restraints at expansion joints or isolate them during test. Unless otherwise noted, minimum test time shall be 4 h plus such additional time as may be necessary to conduct examination for leakage.

G. No pressure drop shall occur during test period. Any pressure drop during test period indicates leakage.

H. Provide pumps, gauges, instruments, test equipment, temporary piping and personnel required for tests and provide removal of test equipment and draining of pipes after tests have been made.

I. For hydrostatic tests, remove air from piping being tested by means of air vents. Measure and record test pressure at high point in system. Where test pressure at high point in system causes excessive pressure at low point in system due to static head, portions of piping system may be isolated and tested separately to avoid

undue pressure. However, every portion of piping system must be tested at the specified minimum test pressure.

J. Conduct pressure tests with parameters indicated below:

System	Minimum Test Pressure	Remarks
Heating hot/Heat Recovery water	100 psig	HYDRO
Chilled water	100 psig	HYDRO

K. Contractor shall provide all pumps, gauges, instruments; test equipment, flow meters, temporary piping and personnel required for tests and provide removal of test equipment and draining of pipes after tests have been made.

L. If piping system is drained after testing and left empty or untreated for more than 3 days, add Nalco 2572 at recommended dosages for dry system lay-up.

3.19 FLUSHING AND CLEANING PIPING SYSTEMS

A. Notify Laboratory and/or Laboratory's representative at least 7 days in advance.

B. Flush new water, fluid systems thoroughly for 15 minutes or longer, as required to ensure removal of dirt and foreign matter from piping system. Bypass pumps and equipment and remove strainers from strainer bodies. Provide circulation by Contractor-supplied portable pumping apparatus.

C. Provide temporary piping or hose to bypass coils, control valves, heat exchangers, other factory-cleaned equipment, and any component that may be damaged.

D. Sectionalize system to obtain minimum velocity of 6 fps. Provide temporary piping to connect dead-end supply and return headers as necessary. Flush bottoms of risers.

E. For pipes 18" and larger, maintain velocity as close as 6 fps possible, but not below 5 fps.

F. After initial flushing of system, use portable pumping apparatus to circulate cold water detergent for water systems. Refer to Section 23 2514 - Chemical Treatment Systems for pipe cleaning.

G. Refer to Section 23 2514 - Chemical Treatment Systems for water analysis.

H. Flush gas piping with clean, dry compressed air for one (1) h minimum. Open and clean drip legs. Repeat flushing until no debris is found in drip legs.

I. Flush compressed air piping with clean, dry compressed air for one (1) h minimum. Open and clean drip legs. Repeat flushing until no debris is found in drip legs.

3.20 INITIAL SYSTEM FILL AND VENT

A. Fill and vent systems with proper working fluids.

B. Use fluids chemically treated as specified in Section 23 2514 - Chemical Treatment Systems.

C. Glycol system shall be filled with treated glycol as specified in Section 23 2514 - Chemical Treatment Systems.

3.21 PIPE PAINTING

A. Exposed exterior carbon steel, black iron or other ferrous pipe and fittings shall be prepared and painted by qualified painters using corrosion inhibitive paints. Pipe shall be prepared in accordance with paint manufacturer's instructions and primed (2 coats) and finish painted (2 coats). Paint type shall be approved by Architect/Engineer.

B. Protect piping from weather and paint promptly to prevent corrosion.

End of Section

SECTION 23 21 18

VALVES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 07 00 - Mechanical Systems Insulation

B. Section 22 16 00 - Natural Gas Piping

C. Section 23 09 02 - Control Valves and Dampers

D. Section 23 21 20 - Piping Specialties (Flow Sensors and Meters)

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 SUBMITTALS

A. Shop Drawings for each system for all sizes including, but not limited to, the following:
   1. Name of system
   2. Manufacturer's name
   3. Type
   4. Model number
   5. Materials of construction
   6. Temperature/pressure ratings
   7. Manufacturer's data sheets clearly cross-referenced
   8. All other appropriate data

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Gate valves, globe valves, check valves, and drain valves: Crane, Nibco, Stockham, Powell, Milwaukee, Hammond, Kitz or Grinnell equal to manufacturer's Figure number listed. Provide valves of same make for these services.

B. Other valves: acceptable manufacturers and Figure Number listed under each item.

2.2 WATER SYSTEM VALVES

A. General:
   1. Valves 2" and smaller, in steel piping shall have threaded ends.
   2. Valves 2" and smaller, in copper piping shall have solder ends.
   3. Provide valve stem extensions with sufficient length to allow for insulation where insulation is specified.

B. Ball Valves:

1. 2" and Smaller: ASTM B584 bronze body, chrome plated brass/bronze or stainless steel ball, full port for 3/4" and smaller and conventional port for 1" and larger, Teflon seat rings, blowout-proof stem, 2-piece construction, 600 psi WOG, 150 psi SWP, Nibco Fig. T(S)-580-70, Apollo No. 70, Watts, Milwaukee BA-150, Hammond, Kitz or Anvil
2. 2" and Smaller: ASTM B584 bronze body, threaded, stainless steel ball and stem, full port, Teflon seat rings, blowout-proof stem, 3-piece construction, 600 psi WOG, 150 psi SWP, Nibco Figure T(S)-595, Apollo, Watts, Hammond, Grinnell, Kitz or Milwaukee

C. Spring Loaded Check Valves:

1. 2" and Smaller: bronze or iron body, Class 125 (200 psi WOG), Nibco Figure T(S)-480, Mueller Figure 303-AP or Metraflex No. 700
2. 2-1/2" and Larger: cast iron body, flanged or wafer type, 316 stainless steel spring, aluminum bronze or carbon steel disc, Buna-N seat, Class 125 (200 psi WOG), Nibco Figure F-910 or W-910, Milwaukee 1800 or 1400, Metraflex No. 700, Stockham Figure WG-970, Mueller Sure Check Model No. 71, or Crane Duo-check II

D. Swing Check Valves:

1. 2" and Smaller: ASTM B62, bronze body, threaded, regrinding, Y-pattern swing type, renewable TFE seat disc, Class 150 (300 psi WOG), conforming to MSS SP-80, Nibco Fig. T-433
2. 2-1/2" and Larger: Iron body, bronze or brass trim, or bronze mounted, renewable seat and disc, Class 125 (200 psi WOG), conforming to MSS SP-71, Nibco Fig. F-918

E. Shut-Off Valves:

1. 2" and Smaller: ball valves as specified in this Section
2. 2-1/2" and Larger: butterfly valves as specified in this Section

F. Balancing Valves:

1. 2" and Smaller: calibrated balancing valves:
   a. Variable orifice with multiple turn valve type as manufactured by Armstrong Series CBV or ABV, Tour & Andersson (Victaulic) Series 786 or 787, NIBCO 1709 or 1710, or fixed orifice with ball valve type as manufactured by Flow Design Inc., Preso, Gerand, Nexus, HCi or Taco. Bronze or brass body, 250 psi maximum working pressure, 250°F maximum operating temperature. Furnish valve with adjustable memory stop and quick disconnect taps with built-in check valve for pressure differential measurement, integral valve setting index and memory locking device.
   b. Valves shall measure down to 0.3 gpm with accuracy of ± 3%.
   c. Valves shall be leak-tight at full rated working pressure.
   d. Unless otherwise indicated, size balancing valves so that at design flow rate, pressure drop across balancing valve with valve approximately 50% open will be at minimum 25% of reading range of meter used for balancing.
2. 2-1/2" and Larger: Armstrong Series CBV or Tour and Anderson (Victaulic) Series 788/789, ductile iron body, ASME/ANSI B16.42 Class 150 flange, 250 psi maximum working pressure, 250°F maximum operating temperature. Fixed orifice with ball valve type as manufactured by FDI, Presco or Gerand, Class 150 flange, 250 psi maximum working pressure, 250°F maximum operating temperature will be acceptable up to 4" size. Butterfly valves, as specified in this Section, together with averaging Pitot tube flow sensors, as specified in Section 23 2120 - Piping Specialties, under Flow Sensors and Meters between check valve and butterfly valve may be used when sizes for Armstrong or T/A valves are not available. Furnish butterfly valves with adjustable memory stops to limit return of valves to preset open position after shut-off.
3. Contractor shall furnish meter for calibration and shall retain meter after final calibration.

G. Terminal Unit Valve Assembly
   1. Terminal unit valve assembly may be used instead of individual valve and other components, provided each valve and component meets specified requirements.
   2. HCi, Nexus or FDI are acceptable.
   3. Inlet assembly shall be combination of isolation ball valve, strainer, union, and PT readout port similar to HCi Terminator Y, and outlet assembly shall be combination of isolation ball valve, union, PT readout ports and venturi flow meter similar to HCi Terminator B.

H. Butterfly Valves:
   1. 2-1/2" and Larger: cast iron or ductile iron body, stainless steel shaft, aluminum-bronze disc with welded nickel edge disc, , upper thrust bearing, EPDM resilient seat, rated at minimum 175 psi CWP for sizes through 12" and 150 psi CWP for sizes 14" and larger, suitable for continuous operation at temperature up to 225°F, compatible to ANSI B16.1 Class 125/150 flange standards, conforming to MSS-SP-67.
   2. Dead end pressure rating shall be minimum 150 psi with no downstream flange/piping attached.
   3. For valves 6" and smaller, provide 10-position lever actuators with locking devices. For valves 8" and larger, provide rotary hand wheel operators with adjustable position stop and position indicators. Size hand wheel operators with no higher than 40 lb rim pull at full valve pressure rating.
   4. Valve necks shall be of sufficient length to allow for insulation where insulation is specified. Wheel shaft shall be sufficient length so wheel does not touch insulation.
   5. Provide full lug type valves permitting removal of down stream piping while using valve for system shut-off.
   6. Furnish valves used for balancing with adjustable memory stops.
   7. Manufacturers: DeZurik, Keystone, Nibco, Milwaukee, Bray, Kitz or Centerline

I. Butterfly Valves (High Performance):
   1. Manufacturers: DeZurik Type BHP, Xomox, Jamesbury, Bray Series 40, or Posi-Seal
   2. Carbon steel or stainless steel body, ANSI Class 150 design rated for 275 psi at 100°F, bubble-tight shut off with pressures in either direction to 275 psi, threaded lug type, upper and lower body bearings with thrust bearings, one piece single or double offset shaft of 316 stainless steel and centerless ground and polished to minimize bearing and packing wear, PTFE seats, PTFE adjustable V-ring packing, capable of service in temperature ranges of -100 to 300°F, 316 stainless steel discs and totally enclosed, factory lubed, handwheel rotary actuator with external disc position indication.
   3. Dead end pressure rating shall be 275 psi without downstream flanging.

J. Water Pressure Regulating Valves:
   1. Manufacturers: Thrush, Watts, Cash-Acme, Taco, or B & G
   2. Brass or bronze body, spring and diaphragm operated, pressure adjustable with check valve and inlet strainer and designed for maximum working pressure of 125 psig and maximum operating temperature of 160°F.

K. Lockshield Valves:
   1. Ball valves as specified above with locking handles for padlocking in open or closed position.

L. Drain Valves:
   1. Ball valve as specified above with threaded hose adapter and cap. Provide 3/4" minimum drain valve for piping larger than 1/2", except strainer blowdown valves shall be blowdown connection size. Provide 1/2" drain valve for 1/2" piping. If 3-piece ball valves are specified, use 2-piece ball valves with same construction.

2.3 STAINLESS STEEL VALVES

A. Gate Valves:

1. 2" and Smaller: stainless steel body, flanged, stainless steel solid wedge, stellite seats, rising stem, union bonnet, malleable iron handwheel, impregnated teflon packing, Class 150 (150 psi WP steam), Williams, Powell or Velan equal to Williams Fig. S15F6-316
2. 2-1/2" and Larger: stainless steel body, flanged, stainless steel solid wedge, stellite seats, impregnated teflon packing, Class 150 (150 psi WP steam), Williams, Powell or Velan equal to Williams Fig. S15F6-316

B. Globe Valves:

1. 2" and Smaller: stainless steel body, flanged, stainless steel disc, stellite seats, impregnated teflon packing, union or screw-over bonnet, malleable iron handwheel, Class 150 (150 psi WP steam), Williams, Velan or Powell equal to Williams Fig. S152F6-316
2. 2-1/2" and Larger: stainless steel body, flanged, stainless steel disc, stellite seats, Class 150 (150 psi WP steam), Williams, Powell or Velan equal to Williams Fig. S152F6-316

C. Swing Check Valves:

1. 2" and Smaller: stainless steel body, flanged, stainless steel disc, Class 150 (150 psi WP steam), Williams, Powell or Velan equal to Williams Fig. S151F6-316
2. 2-1/2" and Larger: stainless steel body, flanged, stainless steel disc, Class 150 (150 psi WP steam), Williams, Powell or Velan equal to Williams Fig. S151F6-316

D. Drain Valves:

1. Gate valve as specified above with hose thread adapter. Provide 3/4" minimum drain valve size except strainer blowdown valves to be blowdown connection size.

2.4 WATER RELIEF VALVES

A. Manufacturers: Kunkle, Consolidated, Thrush, Watts, Cash-Acme, Lonergan, Keckley, or B & G. Iron or bronze body, direct pressure actuated, Teflon seat, stainless steel stem and spring, and suitable for maximum working pressure of 125 psig at 240°F.

B. Valves to conform to State Requirements and have ASME Stamps.

2.5 GAUGE VALVES

A. Unless otherwise indicated, gauge valves for steam, steam condensate and feedwater services shall be gate valves. Gauge valves for all other services shall be needle valves, brass body, 2000 psig, 300°F, similar to Trerice Model 735. Gauge valve size shall match gauge pipe size as specified in Section 23 2116 - Pipe and Pipe Fittings.

2.6 CHAIN WHEEL OPERATORS

A. Similar to Babbitt cast iron or ductile iron adjustable sprocket rims and chain guides. Use galvanized or brass chain and chain closure links to form continuous loop of chain at each operator.

PART 3 - EXECUTION

3.1 GENERAL

A. Install valves as shown on plans, details and according to manufacturer's installation recommendations.

B. After piping systems have been pressure tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust, replace packing or replace valves to stop leaks.

C. Install control valves furnished under Control Systems. Provide increaser and decreaser fittings as required.

D. Refer to Section 23 2116, Part 3 for reducing fittings requirement for valves smaller than pipe size.

E. Provide chain operators for manually operated valves 4" and larger, located more than 8 ft above equipment room floor.

3.2 SHUT-OFF VALVES

A. Provide shut-off valves at all equipment, at riser take-offs at each floor, and at each automatic valve for servicing.

B. Install steam system shut-off valves in horizontal piping. Shut-off valves are not allowed in vertical piping.

3.3 BALANCING VALVES

A. Provide balancing valves where indicated on drawings and as required for complete balancing of water systems.

B. Provide straight inlet and outlet pipe length in accordance with manufacturer's recommendation.

C. For buildings with multiple stories, provide balancing valve in return line at riser take-offs at each floor. Provide shut off valve in supply line at each riser take-off.

3.4 GAUGE VALVES

A. Provide gauge valves at each pressure gauge as shown and at each pressure tapping where pressure sensing tubing is connected.

3.5 DRAIN VALVES

A. Provide drain valves at all low points of piping systems for complete drainage of systems.

3.6 WATER PRESSURE REGULATING VALVES

A. Set valves for pressure required or as scheduled.

3.7 WATER RELIEF VALVES

A. Unless otherwise indicated, provide one relief valve in each closed water system in the pump inlet piping.

3.8 SPRING LOADED CHECK VALVES

A. Provide spring loaded check valve in each pump discharge line.

3.9 SWING CHECK VALVES

A. Provide swing check valves at steam condensate lines if lifted at outlet of traps. Install check valve between trap and gate valve.

End of Section

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SECTION 23 21 20

PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 05 94 - Water Systems Test Adjust Balance

B. Section 23 09 03 - Control Instrumentation (Temperature and Pressure Sensing Requirements)

C. Section 23 21 18 - Valves

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 REFERENCE STANDARDS

A. Metal bellows expansion joints shall be constructed and applied in accordance with "Standards of the Expansion Joint Manufacturer's Association", 8th Edition, 2003.

1.4 SUBMITTALS

A. Shop Drawings for all items in this Section including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the Documents
   3. Materials of construction
   4. Dimensional data
   5. Capacities/ranges
   6. Temperature/pressure ratings
   7. Pressure drop
   8. Expansion joint schedule indicating joint tag no., system, proximity to rotating or reciprocating equipment, required movement in all planes, service pressure, test pressure, service temperature, fluid velocity and cycles to failure (both thermally and seismically, if applicable).
   9. All other appropriate data.

B. LEED Submittal
   1. Product Data for IEQ Credit 4.1: For adhesives and sealants, including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Unless otherwise specified, select devices for highest pressures and temperatures existing in respective systems in accordance with ANSI Specifications.

B. Piping specialties in copper piping shall have bronze or brass body with solder ends.

2.2 THERMOMETERS

A. Manufacturers: Taylor, Trerice, Weksler, Miljoco, Winters, or Weiss

B. Pipeline mounted thermometers: 9" scale cast aluminum case and frame, clear acrylic plastic window front, permanently stabilized glass tube with mercury free indicating fluid, adjustable angle stem, extended neck suitable for insulated piping as required, and compatible with sockets as specified herein.

C. Panel or remote mounted thermometers: vapor actuated dial type with remote bulb, 4-1/2" minimum diameter cast metal casing with double front. Sensing bulbs shall be of length to suit pipe diameter with extended necks as required for insulated piping, suitable for insertion in separable brass sockets as specified herein.

D. Duct type thermometers: dial type with minimum dial size of 4-1/2" and maximum graduations of 2°F, complete with swivel mounting arrangement to permit up to 45° rotation for easy reading.

E. Range of thermometer for particular installation shall extend from point at least 40°F below lowest point of equipment's or system's operating range to point at least 40°F above highest point of that range.

F. Range of thermometers shall be:

Service	Scale Range	Increment
Chilled Water	0°F to 100°F	1°F
Heat Recovery Water	30°F to 180°F	1°F
Heating Hot Water	30°F to 240°F	2°F
Air (indoor)	0°F to 160°F	2°F
Air (outdoor)	-40°F to 100°F	2°F

G. Thermometers by temperature control manufacturer meeting above Specification will be acceptable.

2.3 THERMOMETER SOCKETS AND TEST WELLS

A. Brass construction for carbon steel piping with threaded connections suitable for thermometer bulbs and control sensing devices, well length suitable for pipe diameter with extended neck as required to suit pipe insulation. Trerice 5550 Series or approved equal.

B. For test wells for stainless steel piping, use same material as piping.

2.4 PRESSURE GAUGES

A. Manufacturers: Ashcroft, U.S. Gauge, Marsh, Trerice, Miljoco, Marshalltown, Winters or Weiss equal to Trerice 600 Series

B. Minimum 4-1/2" diameter die cast aluminum case, glass or acrylic plastic window, phosphor bronze bourdon tube with bronze bushed movement, recalibration from front of gauge dial and 1/4" NPT forged brass socket.

C. Gauge accuracy shall meet ANSI B40.100 Grade 1A (1% full scale).

D. Reading range of gauges shall be:

Service	Scale Range
Chilled Water	0 to 100 psig

Service	Scale Range
Heat Recovery Water	0 to 100 psig
Heating Hot Water	0 to 100 psig

E. Pressure Snubbers:
   1. 1/4" or 1/2" size, matching gauge pipe size as specified in Section 23 2116 - Pipe and Pipe Fittings, 1000 psig WP. Brass for carbon steel pipe or copper pipe. Stainless steel for stainless steel pipe.

F. Coil Syphons:
   1. 1/4" or 1/2" size, matching gauge pipe size as specified in Section 23 2116, 500 psig WP. Material shall match gauge pipe material.

2.5 PRESSURE/TEMPERATURE TEST STATIONS

A. Pete's plugs made by Peterson Equipment Company, Sisco, Super Seal by Flow Design Inc. (FDI), or approved equal.

B. Test plugs shall be 1/4" or 1/2" NPT, brass body and cap, 1-1/2" length for non-insulated pipe and 3" length for insulated pipe, with Nordel self-closing valve cores, rated at 500 psig at 275°F, and shall receive either temperature or pressure probe with 1/8" OD.

C. Furnish portable test kit within durable case containing the following:
   1. A compound pressure gauge,3-1/2" dial, 30" Hg – 100 psi, field calibration screw, surge protector and stainless steel gauge adapter with 1/8" diameter probe (2% accuracy of mid range).
   2. Two pocket testing thermometers, 1-3/4" dial, 5" long stainless steel stem, 0 - 220°F and 25 - 125°F ranges with external calibration (1/2% accuracy of entire scale).

2.6 PIPE EXPANSION DEVICES

A. Expansion Loops:
   1. Size expansion loops including L-bends and Z-bends to allow adequate expansion of main straight runs of system within stress limits specified in ANSI B31.1.

B. Expansion Compensators:
   1. Manufacturers: Metraflex, Vibration Mountings and Controls Inc., Hyspan, Expansion Joint Systems, or Flexonics
   2. Compensators shall be constructed of 2 ply stainless steel bellows with carbon steel shrouds and end fittings.
   3. Furnish compensators with internal guides full length of bellows travel and positive internal anti-torque devices to prevent twist or torque during installation. Furnish properly located positioning clips to insure installation at correct end-to-end dimension allowing full rated traverse.
   4. Expansion compensators shall be suitable for system pressure and temperature.

C. Flexible Expansion Loops:
   1. Manufacturers: Metraflex
   2. Flexible expansion loops shall be Metraflex Metraloop consisting of 2 flexible sections of hose and braid, two 90° elbows, and a 180° return, with factory supplied, center support nut located at bottom of 180° return and drain/air release plug.
   3. Flexible loops shall impart no thrust loads to system support anchors or building structure.
   4. Unless otherwise indicated, material of construction, end fitting type and pressure ratings shall be consistent with pipe material, pipe connection fittings and pressure rating as specified in specification Section 23 2116 - Pipe and Pipe Fittings.

5. Hose and braid material shall be 316L.

D. Expansion Joints (Bellows-type):
1. Manufacturers: Flexonics, Metraflex, Expansion Joint Systems, Microflex, American BOA, or Hyspan model 1500 series
2. Expansion joints shall be flanged, packless, constructed of 304 stainless steel bellows and carbon steel fittings.
3. Expansion joints shall be rated for working temperature and pressure of the system, but not less than 150 psig WP.
4. Furnish joints with limit stops or tie rods to prevent over traversing.
5. Furnish external sheet metal shrouds on all expansion joints required to be insulated. Shrouds shall be removable for field inspection of joints. Refer to Section 20 0700 - Mechanical Systems Insulation for insulation requirement.
6. Furnish joints with internal sleeves (liners) constructed of 304 stainless steel with sufficient clearance between bellows and sleeve to permit full rated rotational and lateral movement. Provide drain holes for sleeves as required.

2.7 PIPELINE STRAINERS

A. Manufacturers: Metraflex, Hoffman, Eaton (formally Hayward), Sarco, Keckley, Armstrong, Wheatley, Conbraco or Streamflo

B. Liquid System:
1. 2"and Smaller: full pipeline size, Y-type, with removable screen caps, cast iron, Class 250 (400 psi/150°F WOG), threaded ends for carbon steel piping and bronze, Class 150 (200 psi/150°F WOG),, solder ends for copper piping. Screen caps shall have threaded blowdown connection.
2. 2-1/2" and Larger: full pipeline size, Y-type, Class 125(200 psi/150°F WOG), cast iron, flanged ends. Furnish strainer with bolted screen retainer and off-center blowdown connection.
3. Liquid Service Screens: stainless steel with screen perforation as indicated below. For strainers serving equipment where manufacturer requires specific screen perforation, provide per manufacturer requirements. Maximum pressure drop shall be 4 ft WG through clean strainer.

Pipe Size	Closed System	Open System
2" and smaller	1/32" (20 mesh)	1/8"
2-1/2" to 4”	1/16”	1/8"
5" and over	1/8"	1/8"

2.8 BASKET STRAINERS

A. Cast steel body with Class 150 150 psi flanged ends, full pipeline size with bolted covers. Furnish stainless steel baskets with 1/8" perforations. Provide valved drain connection from each blowdown tapping.

2.9 EXPANSION TANKS

A. Manufacturers: Amtrol, Taco, Bell and Gossett, Armstrong, Wheatley, or Wessels

B. Tanks shall be replaceable bladder type air pre-charged to initial fill pressure as scheduled. Furnish tank suitable for 125 psig WP, constructed, tested and stamped in accordance with ASME Code, and sealed-in elastomer bladder suitable for operating temperature of 240°F. Bladder shall be compatible with water and with ethylene and propylene glycol. Furnish mounting saddles for horizontal tanks and mounting base for vertical tanks. Furnish tanks with system connections; drain connections for floor-mounted tanks, and air charging valves.

2.10 AIR SEPARATORS

A. Manufacturers: Bell and Gossett, Amtrol, Armstrong or Taco

B. 1-1/2" and Smaller: Cast iron construction with steel diffuser tube, bottom and side threaded inlet connections, bottom and top threaded outlet connections, threaded top connection for air elimination, designed for maximum 125 psig WP.

C. 2" and Larger: Cast iron or welded steel construction, flanged and/or threaded connections, perforated stainless steel air collector tube to direct air toward air elimination connection at top of unit, tangential water inlet and outlet connections, bottom blow down connections, constructed in accordance with ASME Boiler and Pressure Vessel Code and stamped for 125 psig design pressure.

2.11 PUMP SUCTION DIFFUSERS

A. Manufacturers: Bell & Gossett, Armstrong, Mueller Steam Specialty, Wheatley or Taco

B. Cast iron or ductile iron body with angle pattern flow straightening vanes and combination diffuser-strainer-orifice cylinder with 3/16" diameter openings, 175 psig WP, at 250°F. Threaded ends for 2" and smaller and flanged ends for 2-1/2" and larger. Orifice cylinder shall have free area of at least 5 times cross section area of pump suction opening. Furnish each unit with disposable fine mesh start-up strainers, gauge tappings, blow down connection, and adjustable support foot to carry weight of suction piping.

2.12 AIR VENTS

A. Manual Air Vents:
   1. Manufacturers: Bell & Gossett Model 4V, 125 psig at 210°F or approved equal. Use 1/2" ball valve for main pipes.

B. Automatic Air Vents:
   1. Manufacturers: Amtrol, Watson McDaniel, B&G, or Hoffman
   2. Metal construction, non-corrosive working parts, 150 psig WP at 240°F
   3. Normal capacity vent shall be similar to B&G Model 87
   4. High capacity vent shall be float actuated and shall have minimum air elimination rate of 10 cfm at 100 psig, similar to B&G Model 107A.

C. Thermostatic Air Vents:
   1. Balanced pressure type, cast bronze body, bronze bellows caged in stainless steel, stainless steel valve and seat, 1/2" threaded connection, 125 psig WSP, equal to Armstrong Model TV-2.

2.13 VACUUM RELIEF/BREAKERS

A. Kadant Johnson Series VB-8 with brass body, stainless steel ball, EPR seat, stainless steel spring, suitable for pressures to 300 psig at 365°F, or Sarco Model VB-14.

2.14 WATER FILTERS

A. Manufacturers: Pall Corporation, Ronningen-Petter, Graver Technologies (Consler), FSI, Filterite or Parker Hannifin

B. Housing shall be constructed of carbon steel for 150 psi WP, constructed in accordance with ASME Code, painted with manufacturer's standard paint.

C. Filter access shall be with bolted and gasketed steel or cast iron head, threaded for 2” and smaller, flanged for 2-1/2” and larger.

D. Cartridge Filter Media:

1. Construct filter cartridges of disposable media with minimum media area of 4-1/2 sq ft per cell.
2. Cartridges to be capable of proper operation at pressure differentials up to 75 psig and temperature to 230°F.
3. Furnish 3 sets of filter cartridges, 2 sets capable of removing 98% of solid particles 5 microns or larger and one set capable of removing 98% of solid particles 75 microns or larger. Use 75 microns filters at initial start-up. When loaded up, replace with 5 microns filters.
4. To insure against by passing, provide positive seal on each cartridge stack consisting of internal tie rod and seal nut arrangement, or equivalent. Single continuous cartridge per stack to be used.

PART 3 - EXECUTION

3.1 GENERAL

A. Install piping specialties as indicated on plans, details and according to manufacturer's recommendations.

3.2 THERMOMETERS

A. Install thermometers in thermowells sockets in locations indicated.

3.3 THERMOMETER TEST WELLS

A. Install test wells in locations as shown and at each point where temperature-sensing device is required under Control Systems.

3.4 PRESSURE GAUGES

A. Install gauges for services with pressure snubbers and gauge valves.

3.5 PRESSURE GAUGE TAPPING

A. Install tappings with gauge valves at each point where sensing device is required under Control Systems and at gauge locations as shown.

B. Use threadolets or tee fittings to mount gauge tappings or test stations. Install fittings for side mounting to avoid collection of air or dirt.

3.6 PRESSURE/TEMPERATURE TEST STATIONS

A. Pete's plug may be used in lieu of thermometer test well and pressure gauge tappings.

B. Use threadolets or tee fittings to mount gauge tappings or test stations. Install fittings for side mounting to avoid collection of air or dirt.

3.7 PIPE EXPANSION DEVICES

A. Install expansion loops, L-bends, Z-bends, and compensators where shown on drawings and as necessary to allow expansion and contraction in piping systems.

B. Flexible Expansion Loops:

1. Install loops in neutral or pre-extend condition as required for application. Install and guide per manufacturer's recommendations.

C. Expansion Joints (Bellows Type):
1. Stretching of expansion joint to correct for piping misalignment or to accommodate available end-to-end spacing shall not be allowed.
2. Remove all shipping rods and spacers and clean inside of expansion joints thoroughly before putting joints into service.
3. Install anchors and guides as specified herein and as shown on drawings prior to putting joints into service.

3.8 PIPELINE STRAINERS

A. Provide drain valve at each strainer blowdown connection with hose threaded adapter and cap. Valve size shall be same as blowdown connection size.

B. Install strainers in water systems on suction side of all pumps, entering side of automatic control valves of heating and cooling coils of air handling units, and as indicated elsewhere.

3.9 AIR SEPARATORS

A. Provide valved blow down connections and extend drain piping to nearest floor drain.

3.10 PUMP SUCTION DIFFUSERS

A. Pipe blow down to the nearest floor drain with drain valve at unit.

B. Remove disposable fine mesh start-up strainers after start-up. Clean permanent strainer and replace after pipe cleaning process.

3.11 AIR VENTS

A. Install manual air vents at all high points in water systems where air may collect and where shown on drawings.

B. Install automatic air vent at top of air separator and where shown on drawings. Provide shut-off valve to isolate air vent from system. Pipe automatic air vent to the nearest floor drain.

C. Install high capacity automatic air vent at air separator.

3.12 THERMOSTATIC AIR VENTS

A. Install thermostatic air vents where shown.

3.13 FLOW ELEMENTS/FLOWMETERS

A. Flow elements/flowmeters located in common piping after multiple pump discharge lines shall be furnished with hot tap feature.

B. If flow elements/flowmeters are furnished by Control Contractor, this Contractor shall install them in accordance with manufacturer's installation instructions. Wiring of flowmeters will be provided by Control Contractor.

3.14 STRAIGHTENING VANES

A. Provide straightening vanes where flow sensor manufacturer's installation instructions require greater length of straight upstream piping than can be obtained in available space.

3.15 WATER FILTERS

A. Install water filter in by-pass arrangement across system pumps. Allow clearance at top of filter for removal of cover and filter changes.

B. Install shut-off valves at filters and pressure gauges for measuring pressure drop across filters.

End of Section

SECTION 23 21 23

PUMPS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 05 13 - Motors

B. Section 20 05 14 - Variable Frequency Drive (VFD) System

C. Section 23 05 50 - Vibration Isolation

D. Section 23 21 20 - Piping Specialties

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:

1. Manufacturer's name and model number
2. Identification as referenced in the documents
3. Capacities/ratings
4. Pump curves with operating point clearly indicated. For parallel pump applications, indicate operating point of combined case as well as operating point of only one pump.
5. Motor data (refer to Section 20 0513 - Motors)
6. Seals
7. Materials of construction
8. Dimensions and weights
9. Manufacturer's installation instructions
10. All other appropriate data

1.4 DESIGN CRITERIA

A. Pump sizes, capacities, pressures and operating characteristics shall be as scheduled.

B. Pumps shall meet or exceed operating efficiencies scheduled.

C. Furnish pumps complete with motors, impellers, drive assemblies, bearings and accessories as hereinafter specified. Furnish pump couplings with OSHA compliant coupling guards.

D. Where pump is indicated for parallel operation, scheduled conditions are for that pump with two pumps operating; i.e., total system flow rate is twice that scheduled for single pump. When only one of two pumps is operating, operating point of that pump must fall within manufacturer's recommended operating range.

E. Select motor with sufficient hp rating for non-overloading operation over entire pump curve.

F. Furnish each pump and motor with nameplate giving manufacturer's name, serial number of pump, capacity in gpm and head in ft at design condition, hp, voltage, frequency, speed and full load current.

G. Test pumps hydraulically at 150% of rated pressure per Hydraulic Institute Standards, clean and paint before shipment. Manufacturer shall certify all pump ratings.

H. Pumps shall operate without objectionable noise or vibration.

I. After completion of balancing, if water balancing results in pump discharge balancing valve being closed 50% or more, replace or trim impeller so that balancing valve is opened at least 75% to maintain design flow rate. Where pumps are driven by VFDs, balancing should be performed with pumps at design speed.

J. Furnish one spare seal for each pump to Laboratory.

K. Head for pumps submitted for pumping through evaporators and condensers of chillers and water coils shall be increased, if necessary, to match the equipment approved for project.

PART 2 - PRODUCTS

2.1 END SUCTION CENTRIFUGAL PUMPS (FLEXIBLE COUPLED)

A. Manufacturers: Bell and Gossett, Taco, Armstrong

B. Pumps shall be base mounted, end suction, flexible coupled, cast iron casing, bronze fitted with working pressure of 175 psi and continuous operating temperature of 225°F. Pump design shall allow for servicing of impeller and bearing assembly without disturbing piping, motor or requiring shaft realignment.

C. Casings shall have tapped and plugged openings for vent, drain, and suction and discharge gauge connections.

D. Impellers shall be single suction enclosed type made of bronze, hydraulically and dynamically balanced to ANSI/HI 1.1-1.5-1994, Section 1.4.6.1.3.1, Figure 1.106 Balance Grade G6.3, keyed and locked to pump shafts and protected by replaceable bronze shaft sleeves.

E. Pump shafts shall be high strength carbon steel, sealed and gasketed from pumped fluid.

F. Chilled water and hot water pumps shall be furnished with mechanical seals with carbon rotating faces, ceramic stationary seats, Buna-N elastomer and 316 SS spring, rated up to 225°F continuous operation.

G. Bearing assemblies shall be cast iron with regreasable ball bearings

H. Spacer type couplings or couplings with extended hubs shall be used to allow for pump servicing.

I. Pumps shall be furnished with groutable steel base plates

2.2 IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers: Bell and Gossett, Taco, Armstrong or Aurora

B. Pumps shall be pipeline mounted, single suction type with cast iron casing, bronze fitted with working pressure of 175 psi and continuous operating temperature of 225°F.

C. Casings shall have tapped and plugged openings for vent, drain, and suction and discharge gauge connections.

D. Impellers to be single suction enclosed type made of bronze, hydraulically and dynamically balanced, keyed and locked to pump shafts and protected by replaceable bronze shaft sleeves.

E. Impellers shall be directly hung from motor shafts without using flexible couplings.

F. Pump shafts shall be high strength carbon steel or alloy steel, sealed and gasketed from pumped fluid.

G. Pumps shall be furnished with mechanical seals of single unbalanced type with carbon rotating faces, ceramic stationary seats and Buna-N elastomer.

H. Bearing assemblies and motors shall have oil lubricated sleeve bearings or regreasable ball bearings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pumps in strict accordance with manufacturer's instructions to avoid any stress and misalignment.

B. Set base mounted pumps on concrete bases, or concrete inertia base, level and bolt down prior to grouting. Fill entire base with non-shrinking grout. Use end caps during grouting to prevent overflow when end caps are not integral with base plates.

C. Align flexible coupled pumps after base grouting is complete. Align pump and motor in all four planes: vertical angular, horizontal angular, vertical parallel and horizontal parallel. Alignment shall be within the recommended value by manufacturer, but not over 1/64” for parallel alignment and 1/64” per inch of coupler radius for angular alignment. Record and submit all results of alignment procedure to Engineer. After alignment is complete, pin pump and motor to base.

D. Set close-coupled pumps on concrete bases using flush type anchors and cap screws to allow for pump servicing. Use of threaded rod will not be allowed.

E. Install full line size spring loaded check valve and balancing valve in pump discharge piping.

F. Where pump connection size and indicated line sizes are not identical, provide necessary concentric reducers/increasers for vertical piping at pump connection and eccentric reducers/increasers for horizontal piping at pump connection. Install eccentric reducers/increasers with top of pipe level. Valves and piping specialties shall be full line size as indicated on drawings.

3.2 STARTUP

A. Verify that piping system has been flushed, cleaned and filled.

B. Prime pump, vent air from casing and verify that rotation is correct. To avoid damage to mechanical seals, never start or run pump in dry condition.

C. Verify lubrication of motor and pump bearings and lubricate properly in accordance with manufacturer’s recommendation and Section 20 0000, Part 3, under LUBRICATION.

D. After several days' operation, verify removal of disposable startup strainer in suction diffuser and turn them over to Laboratory.

E. Perform field mechanical balancing, if necessary, to meet vibration tolerance specified in Section 23 0550 - Vibration Isolation.

F. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.3 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

SECTION 23 25 14

CHEMICAL TREATMENT SYSTEMS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 09 93 - Control Sequences

B. Section 23 21 16 - Pipe and Pipe Fittings

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 SUBMITTALS

A. Shop Drawings for each system including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Capacities/ratings
   3. Chemicals; description of chemicals, its composition and function
   4. Operating sequence
   5. Composite wiring diagrams
   6. Materials of construction
   7. Dimensions and weights
   8. Manufacturer's installation instructions
   9. All other appropriate data

B. Submit overall installation diagram for each system locating chemical injecting points, bleed-off assemblies, water meters, number of tanks and pumps, and field piping.

C. Submit complete make-up water analysis.

D. Submit directly to Laboratory, Material Safety Data Sheets (MSDS) for all chemicals used in chemical treatment systems. Include with MSDS written notice of Laboratory's responsibility to notify its employees of the use of those chemicals.

1.4 OPERATION AND MAINTENANCE DATA

A. Provide for services of manufacturer's trained, representative to approve installation, and instruct Laboratory's representative in operation, testing and maintenance of each system.

B. Include data on chemical feed pumps, meters, and other equipment including spare parts lists, procedures, and treatment programs. Include step-by-step instructions on test and adjust procedures including target concentrations.

1.5 MAINTENANCE SERVICE

A. Service shall be provided by Nalco for all closed loop systems. Coordinate with Laboratory for service requirements.

1.6 WATER ANALYSIS

A. Submit complete water analysis and results of performance test of each system signed by manufacturer's service representative.

B. Water analysis shall include the following:
   1. Hot and/or Chilled Water:
      a. Hardness
      b. pH
      c. M" alkalinity
      d. Inhibitor level
      e. Total dissolved solids
      f. Temperature

1.7 DESIGN CRITERIA

A. Periodic test procedure and chemical shall be recommended for each system.

B. Chemicals shall be suitable for pipe material, fluid medium and intended treatment.

C. Materials of construction for equipment used shall be compatible with water treatment chemicals provided.

D. Treat the following systems:
   1. Hot water (Heat recovery heating hot water system)

E. Provide initial chemical treatment and equipment for all systems based on complete system fluid analysis, including make-up water, prior to equipment installation. Coordinate chemical treatment of systems (chilled water and low temperature heating hot water) with Laboratory prior to connecting into Area 400 systems.

F. Initial supply of chemicals for chemical treatment of each system shall be adequate for start up and testing period, for the time systems are being operated by Contractor for temporary heating and cooling, and for 1 yr after start-up of system.

G. Inhibitor for closed water systems shall use nitrites or phosphonate as primary inhibitor.

H. Provide electrical devices, wiring and conduit in accordance with the applicable sections of Division 26.

1.8 WATER QUALITY REQUIREMENTS

A. Minimum water quality requirements for closed hot and/or chilled water systems shall be as follows:

1.	pH	7.5 – 9.0
2.	TDS	same level of make-up water
3.	Conductivity	same level of make-up water
4.	Iron	same level of make-up water
5.	Dissolved Oxygen	<0.04 mg/kg

6. Ryznar Index >6.0
7. Suspended Solids ≤10 µm
8. Bacteria Counts (Chilled Water System) ≤100 cfu per mL

PART 2 - EXECUTION

2.1 MANUFACTURERS

A. Manufacturers: Nalco (Laboratory's service provider)

2.2 PIPING SYSTEM CLEANER

A. Use cleaning compound similar to Nalco 2567 to remove organic soil, hydrocarbons, flux, pipe mill varnish, pipe compounds, iron oxide, and like deleterious substances, with or without inhibitor, suitable for system metals without deleterious effects. Cleaner shall not contain phosphate.

2.3 HOT WATER CHEMICAL TREATMENT (HEAT RECOVERY HEATING HOT WATER SYSTEM)

A. Provide by-pass type batch feeder to receive chemicals in liquid or pellet form. Each independent hot water heating system shall have separate feeder. Chemical treatment shall control corrosion and scale.

B. Feeder shall have capacity of 5 gal and shall be constructed of steel with minimum working pressure of 150 psig. Feeder shall be complete with air vent, drain valve, inlet ball valve, and outlet balancing valve, and unions.

C. Furnish feeders with screw type cover with replacement gaskets, or valved funnel opening and with exterior prime coat finish.

2.4 TEST CABINET AND EQUIPMENT

A. Provide complete chemical treatment test equipment and cabinet with appropriate reagent, burettes, and glassware to conduct all tests necessary for determination of proper treatment and blowdown.

B. Provide detailed, written test procedures for each system in manual with plastic protection cover for each page.

C. Test equipment shall include but not be limited to, the following:
   1. Closed Loop Water System:
      a. Inhibitor test kits

D. Provide bypass type batch feeder to receive chemicals in liquid or pellet form.
   1. Feeder shall have capacity of 2 gal and shall be constructed of steel with minimum working pressure of 150 psig. Feeder shall be complete with air vent, drain valve, inlet and outlet globe valves, and unions.
   2. Furnish feeders with screw type cover with replacement gaskets, or valved funnel opening and with interior epoxy coating and exterior prime coat finish.

PART 3 - EXECUTION

3.1 ELECTRICAL WIRING

A. Provide all field electrical wiring for system, in metal conduit and in accordance with Division 26 and all applicable Electric Codes.

3.2 APPLICATION OF CHEMICALS

A. Apply initial chemical treatment for each system after systems have been cleaned and flushed.

B. Add, adjust or modify treatment based on results of period tests until turned over to Laboratory.

3.3 PERFORMANCE TEST

A. Conduct performance test for each system to determine required capacity and performance of chemical treatment system. Refer to Part 1 for water analysis and water quality requirements.

B. Conduct water quality test in all systems weekly and submit test result reports to Mechanical Contractor and Laboratory until project is turned over to Laboratory.

C. Conduct water quality tests before and after new work tie-in to existing systems.

3.4 BATCH FEEDERS

A. Install in bypass arrangement at pump discharge as indicated.

3.5 PIPE CLEANING

A. General:
   1. Piping systems shall be cleaned before they are used for any purpose except pressure tests, which shall be conducted before cleaning. Add cleaner to closed systems at concentrations as recommended by cleaner manufacturer. Remove water filter elements from system before starting circulation.
   2. Use neutralizer agents on recommendation of system cleaner supplier and approval of Architect/Engineer.
   3. Remove, clean, and replace strainer screens or filters.
   4. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed.
   5. New piping system shall not be connected to existing system for operation until flushing and cleaning have been completed. Obtain permission from Laboratory prior to opening up new work to existing system.

B. Water Systems:
   1. Piping systems shall be filled, vented and circulated employing chemical cleaner solution for period of at least 24 h or more in accordance with manufacturer's recommendations and job site chemical tests. Bring concentration to level, which raises M Alkalinity to manufacturer's recommended value above that for existing water used for fill. Conduct chemical tests to verify levels and submit results to Architect/Engineer. Flush detergent clear with continuous draining and make-up water fill for period of at least 12 h or more until original M Alkalinity level is achieved (or until pH of system water is within 0.5 pH of make-up water). Conduct chemical tests to verify levels and submit results to Architect/Engineer. When cleaning process is complete, replace strainers or filters and reconnect permanent pumping apparatus. Obtain permission from Laboratory prior to opening up new work to existing system.

End of Section

SECTION 23 31 14

DUCTWORK

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 05 29 - Mechanical Supporting Devices

B. Section 20 07 00 - Mechanical Systems Insulation

C. Section 23 05 50 - Vibration Isolation

D. Section 23 05 95 - Air Systems Test Adjust Balance

E. Section 23 09 02 - Control Valves and Dampers

F. Section 23 33 14 - Ductwork Specialties

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 SUBMITTALS

A. For each duct system, submit schedule utilizing reinforcement tables from SMACNA HVAC Duct Construction Standards Metal and Flexible where applicable. Each duct system schedule shall include, but not be limited to, the following:

1. Name of Contractor/manufacturer fabricating each duct system
2. Material and gauge
3. Pressure class
4. Transverse joint type and length and reinforcement rigidity class with designated joint T number or proprietary duct connection if utilized for each system
5. Certified test results of proprietary joint products, if used, tested in accordance with SMACNA procedures
6. Intermediate reinforcement spacing and rigidity class with metal angle dimensions and gauge
7. Type of longitudinal seam
8. Fitting construction details
9. Support methods including spacing, upper attachments, and lower attachments
10. Sealant and gasket
11. Sealing class

B. Duct leakage testing methods, apparatus and apparatus certification signifying meter is in conformance with ASME Requirements for testing meters.

C. Duct liner including data on thermal conductivity, air friction correction factor, and temperature and velocity limitation.

D. Coordinated shop drawings.

E. Submit the following information for welded sheet metal ductwork:
   1. Welding Procedure Specification (WPS) for welded joints. Form to be similar to ANSI/AWS D9.1-2006 Code, Appendix "D".
   2. Procedure Qualification Record (PQR) for each WPS. Form to be similar to ANSI/AWS D9.1-2006 Code, Appendix "E".
   3. Welder and Welding Operator Qualification Test Record (satisfactory performance) for each field or shop welder. Form to be similar to ANSI/AWS D9.1-2006 Code, Appendix "F".

F. LEED Submittals:
   1. Product Data for IEQ Prerequisite 1: Documentation indicating that duct systems comply with ASHRAE 62.1-2007, Section 5 – "Systems and Equipment".
   2. Product Data for EA Prerequisite 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1-2007, Section 6.4.4 – "HVAC System Construction and Insulation".
   3. Leakage Test Report for EA Prerequisite 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1-2007, Section 6.4.4.2.2 – "Duct Leakage Tests".
   4. Duct Cleaning Test Report for IEQ Prerequisite 1: Documentation of work performed for compliance with ASHRAE 62.1-2007, Section 7.2.4 – "Ventilation System Start-Up".
   5. Product Data for IEQ Credit 4.1: For adhesives and sealants, including printed statement of VOC content.

G. Structural Submittals:
   1. Where loads imposed exceed design superimposed dead loads or suspended loads specified in contract documents, submit for approval to Structural Engineer of Record loads imposed on the primary structural frame. Submittal shall include location, magnitude and direction of imposed loads (basic, unfactored load cases), graphically represented in their appropriate location on a copy of the contract document structural framing plans or elevations as appropriate. Detail references indicating the connections applicable at each location shall be noted on the submittal drawings.

1.4 DELIVERY, STORAGE AND HANDLING

A. Protect duct and fittings from damage due to normal handling during shipment and storage. Protection shall be applied to ends of duct to prevent dirt and moisture from entering ducts and fittings.

1.5 DESCRIPTION

A. Furnish and erect ductwork free of objectionable vibration, chatter, and pulsations. Verify dimensions at site, making field measurements and drawings necessary for fabrication and erection.

B. Duct sizes indicated are net inside dimensions.

C. Where size for a duct segment is not indicated, the duct segment size shall be equal to the largest duct segment to which it is connected. Transition to smaller size shall occur on side of fitting where smaller size is indicated.

1.6 DESIGN CRITERIA

A. All products shall conform to NFPA 90A, and shall possess flame spread rating of not over 25 and smoke developed rating no higher than 50.

B. Unless otherwise indicated, construct all ductwork of galvanized sheet metal for pressure class not less than 2" WG for positive pressure ductwork and not less than -2" WG for negative pressure ductwork.

C. Ductwork shall comply with Local, State and Federal requirements.

D. Unless otherwise indicated, pressure class for VAV system supply ductwork between supply fan discharge and air terminal device inlet shall be equal to static pressure at fan discharge but not less than 4" WG; pressure class for ductwork on suction side of air handling unit and suction side of return fan shall be equal to static pressure at inlet of return fan but not less than -2" WG.

E. Unless otherwise indicated, pressure class for fume hood exhaust ductwork between exhaust fan inlet and exhaust valve outlet shall be equal to static pressure at exhaust fan inlet but not less than -4" WG.

F. Unless otherwise indicated, pressure class for constant air volume system ductwork shall be equal to external static pressure (fan entrance or discharge pressure minus associated unit internal component pressure drop), but not less than ± 2" WG.

G. Duct transverse joints and reinforcement material, including angle ring flanges and stiffeners, shall be of same material as duct.

H. Except as modified in this Section of specifications, use material, weight, thickness, gauge, construction and installation methods as outlined in the following SMACNA publications:

1. HVAC Duct Construction Standards Metal and Flexible, 3rd Edition, 2005, for rectangular and round ductwork up to positive 10" WG and negative 10" WG and flat oval ductwork up to positive 10" WG.
   a. Internal tie rods or bracing are not allowed for ductwork 40" and smaller. Tie rods shall be 1/2" or 3/4", galvanized steel EMT/conduits with bolt assembly consisting of rubber washer and friction anchored threaded insert similar to Ductmate Easyrod or PPI Condu-Lock.
   b. Internal tie rods are not allowed for welded ductwork and special exhaust systems, such as fume hood exhaust, BSC exhaust, animal room exhaust, BSL-3 exhaust, cagewash exhaust, shower room exhaust, kitchen hood exhaust, dishwasher exhaust, etc.
   c. Midpanel tie rods described in SMACNA Addendum No. 1, November 1997, are not allowed.
2. Round Industrial Duct Construction Standards, 2nd Printing 1999

1.7 WELDING REQUIREMENTS

A. The following requirements cover arc and braze welding of nonstructural sheet metal ductwork for HVAC, architectural metal and other FDA process applications where pressures do not exceed 120" WG (positive or negative). These requirements also apply to welding of structural members whose sole purpose is stiffening, supporting, or reinforcing of sheet metal material, as well as attachment of brackets or other accessories/components required to provide complete systems.

B. Procedure and Qualification:

1. Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) shall be prepared by installing contractor and/or fabricator prior to execution of related work. Qualification of welding procedure shall meet or exceed requirements of the latest revision of American Welding Society, Sheet Metal Welding Code ANSI/AWS D9.1.
2. Provide certification of satisfactory performance testing for all welders and welding operators, which provide welding services on Project.
3. Establish and provide written quality assurance/quality control (QA/QC) procedures to ensure compliance with specification requirements. Clearly identify appropriate steps for safe welding procedures (review Appendix J of D9.1) including additional safety material, screens, eye, personnel and clothing protection, fire suppression equipment, and fume extraction equipment needed adjacent to welding work area.

PART 2 - PRODUCTS

2.1 GALVANIZED STEEL SHEET

A. First quality, Lock Former Quality (LFQ), cold rolled, open hearth soft steel sheet capable of double seaming without fracture, ASTM A924 or ASTM A653. Galvanized coating shall be G90.

B. Use G90 Galvaneal or Zincgrip where painting is specified.

2.2 ALUMINUM SHEET

A. Aluminum alloy, ASTM B209, Type 3003H-14 capable of double seaming without fracture.

2.3 STAINLESS STEEL SHEET

A. First quality, cold rolled annealed, pickled, ASTM A240 and A480, Finish No. 2B for concealed work and Finish No. 4 for exposed work. Unless otherwise indicated, use Type 304L where welded duct construction is specified and Type 304 where non-welded duct construction is allowed.

2.4 FLEXIBLE DUCT

A. Manufacturers: Thermaflex, Casco, or Flexmaster, similar to Thermaflex Model M-KE or Flexmaster Type 6

B. Factory fabricated, UL listed under UL-181 as Class 1 duct, meeting requirements of NFPA 90A with flame spread of 25 or less and smoke developed rating of 50 or under.

C. Flexible duct shall be suitable for:

1. Operating Temperature: -20ºF to -250ºF
   Operating Pressure: +6” WG(14”-16” ID)
   -1” WG(4”-12” ID)
   -0.5” WG(14”-20” ID)
2. Velocity: 00 fpm

D. Unless otherwise indicated, duct shall be nonmetallic insulated type composed of polyester film, polyethylene film, nylon film or coated woven fiberglass liner bonded permanently to corrosion resistant coated steel wire helix.

E. Insulation shall be minimum 1” fiberglass insulation blanket with maximum thermal conductance of 0.23(Btu·in/(hr·ft^2·°F)) at 75ºF. Vapor barrier jacket shall be aluminum foil reinforced, polyethylene, or metalized polyester film with minimum perm rating of 0.05 perm.

F. Insulation material shall not be exposed to air stream.

G. Lined flexible duct shall have the following minimum acoustical performance in accordance with ARI Standard 885. Dynamic Insertion Loss in each octave band of 5 ft or 10 ft straight duct shall not be less than the following:

Duct Diameter (in)	Dynamic Insertion Loss (dB) Octave Band Center Frequency (Hz) (Based on 5 ft length)					
	125	250	500	1000	2000	4000
6”	6	9	18	22	24	15

8”	6	10	18	20	21	12
10”	5	11	18	18	18	9

Duct Diameter (in)	(Based on 10 ft length) 125	250	500	1000	2000	4000
6”	10	15	28	33	35	22
8”	10	18	29	32	32	20
10”	9	19	28	31	29	18

2.5 SNORKEL DUCT CONSTRUCTION

A. Equal to Dura-Vent Model 2PA, two-ply polyester-acrylic urethane blend coating, white color, -40ºF to 250ºF.

B. Use stainless steel ductwork for snorkel to the point connected to main exhaust ductwork.

2.6 GLASS FIBER DUCT LINING

A. Manufacturers: Manville, Owens-Corning, Knauf or Certainteed

B. Lining shall be made of long textile-type glass fibers, 1” thick with 3.0 pcf density.

C. Lining shall meet the following:
1. Acoustical performance per ASTM C1071
2. Erosion test per UL 181
3. Fungi and bacteria resistance per ASTM C1338
4. Water vapor absorption per ASTM C1104
5. Corrosion resistance per ASTM C665
6. Thermal Conductivity of not more than 0.24 (Btu·in/(h·ft^2·°F)) at 75°F mean temperature per ASTM C518
7. Air friction correction factor not exceed 1.15 at 2000 fpm
8. Suitable for air velocities to 5000 fpm per ASTM C1071 and temperatures to 250ºF per ASTM C411
9. Adhesives to comply with ASTM C916

2.7 LABORATORY EXHAUST FANS DISCHARGE STACKS

A. Manufacturers: Metalbestos, AMPCO, Schebler or Van-Packer, equal to Metalbestos Model G

B. Model G stack shall be factory built, type 316L stainless steel in 0.035” minimum thickness. Stack shall be self-supporting without guy wires.

C. Provide stack system complete with all necessary accessories including flashing, storm collar, 45° lateral tee fitting, drain tee cap, plate support assembly and necessary supports.

D. Induction Nozzle: Air induction discharge nozzle shall be supplied by fan manufacturer, be integral to stack design, and be designed to efficiently handle outlet velocity of up to 7000 fpm.

2.8 DUCT SEALANT AND GASKET

A. Sealant:
1. UL Classified sealant as compounded specifically for sealing joints and seams in ductwork. Hardcast, McGill AirSeal, Ductmate, Mon-Eco Industries or H.B. Fuller/Foster. Duct tapes are not allowed.

2. Select sealants as recommended by manufacturer for specific application.
3. Submit sealant manufacturer's data sheets including performance data, pressure ratings, surface burning characteristics data, detailed installation instructions.

B. Gaskets:
1. Butyl, copolymer or neoprene based tape similar to Ductmate 440 Gasket Tape or Neoprene Gasket Tape for flanged joints.

C. Duct Sealant and Gaskets for Fume Hood Exhaust Ductwork:
1. Sealant shall be similar to Hardcast Sure-Grip 404 or Ductmate Proseal.
2. Gasket material shall be Butyl tape similar to Ductmate 440 Gasket tape or neoprene gaskets.
3. Gasket thickness and width shall be as required for flange and surface irregularities to seal joint air tight.

D. Provide filter system on duct inlet to test blower. Filter system to be equal to final filtering efficiency of the AHU supply air duct system. Not required for negative pressure testing.

2.9 CABLE SUSPENSION SYSTEM

A. Suspension system shall be Gripple Hang-Fast as manufactured and supplied by Gripple Incorporated.

B. Suspension system shall be load rated and verified by SMACNA Testing and Research Institute to be in compliance with SMACNA HVAC Duct Construction Standards, 2005, Chapter 5.

PART 3 - EXECUTION

3.1 GENERAL

A. Install ductwork parallel to building walls and ceilings and at such heights not to obstruct any portion of ceiling, window, doorway, stairway, or passageway. Install ductwork to allow adequate access and service space for equipment. Refer to drawings and/or manufacturer's recommendations. Install vertical ductwork plumb. Where interferences develop in field, offset or reroute ductwork as required to clear such interferences. In all cases, consult drawings for exact location of duct spaces, ceiling heights, door and window openings or other architectural details before installing ductwork.

B. Make allowances for beams, pipes or other obstructions in building construction and for work of other contractors. Check plans showing work of other trades and consult with Engineer in event of interference. Transform, divide, or offset ducts as required, in such a manner as to maintain same cross sectional area of duct as indicated on drawings. Where it is necessary to install pipes or similar obstructions through ducts, consult with Engineer and obtain written approval from Engineer and Laboratory. If approved, provide streamlined encasement or collar designed in accordance with SMACNA Standards and seal to prevent air leakage.

C. Ductwork shall be free of kinks and dents.

D. Fabricate and install duct, fittings, joints, seams, reinforcement, supports, sealing, liner, etc., in sizes indicated on drawings and in accordance with manufacturer's published data and SMACNA Standards except as modified in this Section of Specifications.

E. Provide transitions where different size or different shape ductwork segments are connected. Use concentric transitions unless otherwise shown. Unless otherwise indicated, make diverging transitions with maximum angle of 15° per side (30° total diverging) and converging transitions with maximum angle of 25° per side (50° total converging).

F. Provide transitions at ductwork system components and connections to equipment. Refer to Specification Section 23 3713 – Diffusers, Registers, and Grilles, for additional information regarding diffuser/register/grille connections.

G. Refer to ductwork symbols list on drawings for additional and dimensional requirements for fittings.

H. Seal duct seams and joints to meet SMACNA Class A as minimum for all ductwork including low-pressure ductwork.

I. Construct ductwork so that interior surfaces are smooth. Internal duct hangers and internal bracing are not allowed. Refer to Part 1, Design Criteria for internal tie rods.

J. Support coils, filters, air terminals, dampers, sound attenuator devices or other devices installed in duct systems with angles or channels, and make all connections to such equipment including equipment furnished by others. Secure frames with gaskets, nuts, bolts and washers.

K. Air terminal devices may be supported by strap hangers if air terminal manufacturer approves. Strap hangers are not allowed for fan powered devices, double wall type and Titus Steri-Loc type devices.

L. Install outside air intake duct to pitch down at minimum 1” per 20 ft toward intake louver or plenum and to drain to outside of building. Solder or seal seams to form watertight joints.

M. Blank off unused portion of outside air intake or exhaust louvers.

N. Where 2 different metal ducts meet, install joint in such a manner that metal ducts do not contact each other by using proper gasket seal or compound.

O. Install motor operated dampers and connect to or install equipment furnished by others. Provide necessary blank-off plates or transitions to mount control dampers as specified in Section 23 0901 - Control Systems Integration.

P. Do not install ductwork over electrical panelboards, switchgear, switchboards or motor control centers.

Q. When original galvanized finish is altered or damaged, apply field galvanizing paint as follows:
   1. Prepare surface with use of power sanders or wire brushes to remove rust, paint, etc.
   2. Apply cold galvanizing material equal to ZRC Products, Inc.

3.2 ELBOWS

A. Rectangular Duct:
   1. Unless specific type is indicated, use radius elbows with minimum centerline radius to width or diameter ratio of 1.5. Where 1.5 radius elbows do not fit, use the following elbows.
      a. Supply Air Ductwork:
         1). 1.0 radius elbows
         2). Square throat elbows with turning vanes where 1.0 radius elbows do not fit
      b. Return or Exhaust Air Ductwork:
         1). 1.0 radius elbows with full splitter vanes (SMACNA Type RE3) as follows:
            a). One vane for duct width 24” to 48”
            b). Two vanes for duct width 49” to 72”
            c). Three vanes for duct width 73” and larger
            d). Fabricate vanes in accordance with SMACNA HVAC Duct Construction Standard, chart 4-1 (p 4.11) and Figure 4-9 (p 4.13).

2). 45° throat with radius heel elbows with full splitter vanes as follows where 1.0 radius elbows do not fit:

a). One vane for duct width 12” to 24”

b). Two vanes for duct width 25” to 36”

c). Three vanes for duct width 36” and larger

d). Fabricate vanes in accordance with SMACNA HVAC Duct Construction Standards, Chart 4-1 and Figure 4-9.

3). Square throat - radius heel elbows or square throat elbows with turning vanes are not allowed unless specifically indicated.

B. Round and Oval Duct:

1. Unless specific type is indicated, use radius elbows with centerline radius to diameter ratio of 1.5. Where 1.5 radius elbows do not fit, use 1.0 radius elbows.

3.3 LONGITUDINAL SEAM

A. Rectangular Duct:

1. Unless otherwise indicated, use Pittsburgh lock seam for rectangular ductwork.
2. Button punch snap lock construction (SMACNA L-2) may be used for ductwork for 2” WG and lower, and sizes 48” and smaller in width.
3. Button punch snap lock construction is not allowed for ductwork in chases and areas above inaccessible ceiling.
4. Button punch snap lock construction is not allowed on aluminum ductwork.

B. Round and Oval Duct:

1. Unless otherwise indicated, longitudinal seams shall be in accordance with SMACNA HVAC Duct Construction Standards. Snaplock seams are not allowed.

3.4 TRANSVERSE JOINT

A. Rectangular Duct:

1. Transverse joints shall be in accordance with SMACNA HVAC Duct Construction Standards.
2. Ductmate 25/35 connection systems with corner clips or optional nuts and bolts may be used. Incorporate use of all Ductmate accessories to ensure integrity of transverse connection. Install joints in strict accordance with the latest edition of Ductmate 25/35 Assembly and Installation Instruction Manual and Duct Construction Standards. Nexus or WDCI will be acceptable.
3. Lockformers TDC or Engles TDF may be used in accordance with T-25 flanges of SMACNA HVAC Duct Construction Standards Metal and Flexible, 2005, provided that corner pieces with bolts are used. If TDF/TDC flanges are damaged, replace the damaged joint(s) by straightening and reinforcing with minimum 1-1/2” x 1-1/2” x 1/4" angle at each side of transverse joint.
4. Refer to Detail for non-externally insulated outdoor ductwork.

B. Round and Flat Oval Duct:

1. Unless otherwise indicated, use beaded sleeve joints (SMACNA RT-1) with minimum 2” insertion length or flange joints (SMACNA RT-2 or RT-2A).
2. Connection systems manufactured by Ductmate Industries (Spiralmate and Ovalmate) or McGill AirFlow (Uni-flange) may be used for supply air ductwork.
3. AccuFlange connected systems may be used with gaskets specified in Part 2 of this Section.

3.5 DUCT SUPPORTS

A. Unless otherwise indicated, use straps or Z bar hangers with 3/8” rods to support rectangular ducts 60” wide and smaller and trapeze hangers with rods or angles to support rectangular ducts over 60” wide.
   1. Use trapeze hangers to support externally insulated ductwork with weight bearing inserts. Refer to Section 20 0700 – Mechanical Systems Insulation and details.

B. For round ducts 24” diameter or smaller, use single hanger.
   1. Cable Suspension System may be used up to 16” diameter at spaces higher than 8 ft above floor or platform.
   2. Round Duct Strap Bracket by Ductmate Industries may be used up to 24” diameter.

C. Refer to Section 20 0700 - Mechanical Systems Insulation for ductwork insulation, weight bearing inserts and insulation protection shield requirements.

D. Support ducts located on roof as detailed.

E. Support vertical ducts at every floor, but not exceeding 12 ft.

F. Support flexible duct at manufacturer’s recommended intervals but at least every 5 ft. Maximum sag shall be 0.5” per ft between supports. Hanger or saddle material in contact with flexible duct shall be minimum 0.5” wide.

G. The following upper attachments, upper attachment devices, lower hanger attachments, hanger devices, and/or hanger attachments are not allowed except where specifically indicated:
   1. Nailed pin fasteners
   2. Expansion nails without washers
   3. Powder charged or mechanically driven fasteners (forced entry anchors). Forced entry anchors may be used for upper attachments of flexible ductwork supports.
   4. Beam or "C" clamps without retaining clips or friction clamps (provide retaining clips for "C" clamps)
   5. Non-factory manufactured upper attachments for metal pan deck including wire coil and double circle (Items 16 and 17 of Fig 5-4 of SMACNA HVAC Duct Construction Standards 2005)
   6. Wire hanger
   7. Trapeze hangers supported by wires or straps
   8. Rods, straps or welded studs directly attached to metal deck
   9. Drilled hole with attachment to structural steel
   10. Lag screw expansion anchor
   11. Non-metallic hangers or straps

H. Supporting devices shall be standard products of manufacturers having published load ratings.

I. Refer to Section 20 0529 - Mechanical Supporting Devices for additional support requirements including attachments to structures.

J. For welded ducts, soldered ducts or ducts with water tight joints, do not use supports utilizing screws or other penetrations into ductwork.

K. Unless Architectural Documents indicate the required framing, provide angle iron framing around roof opening where duct penetrates through roof decking, to maintain roof decking structural integrity in accordance with roof decking manufacturer's recommendations. This is not required for concrete decking. For concrete decking, consult with the project structural engineer for location and size of opening prior to execution of Work.

3.6 SHEET METAL WELDING

A. Welded ductwork shall be butt-welded unless otherwise indicated. Backing material and slip joints are not allowed.

1. SMACNA T-21 or T-21a welded flange joints are acceptable with continuous welding including at each corner for rectangular ducts.

B. Attach welding cable leads directly to base metal to be welded. Do not jumper welding cable leads through building structure, to avoid emission of stray voltage/current through building structure.

C. Welds on exposed ductwork in occupied spaces shall be brush polished with stainless steel brush.

D. Welds at exterior of building shall be ground smooth and brush polished with stainless steel brush to prevent atmospheric contamination and rust formation.

3.7 PROTECTION OF DUCTWORK

A. Protect ductwork during construction against entry of foreign matter and construction dirt.

B. Keep ductwork capped when work is complete for the day or when duct is not being worked on or added to. Use of polyvinyl (VISQUEEN) with duct tape wrap is an adequate measure as long as it is secure with no openings or tears in product.

C. If ductwork is not protected, remove dirt and foreign matter from the duct system and obtain inspection and approval from Engineer upon completion of cleaning before operating fans.

D. Return fans are not allowed to operate during construction to avoid intake of construction dirt/dust into return air ductwork.

3.8 DUCT LEAKAGE TEST

A. Refer to Test and Balancing portion of Section 20 0000 - General Mechanical Requirements.

B. Laboratory and/or Laboratory's representative may elect to witness leakage tests. Notify Laboratory and/or Laboratory's representative at least 3 days in advance.

C. Test 25% of total duct area of each supply and general exhaust ductwork from fan to air terminal devices where air terminal devices are used, unless otherwise indicated in this section or in schedules.

D. Test 100% of total duct area of fume hood exhaust ductwork from fan to fume hood and from fan discharge to top of stack.

E. Leakage test procedures shall be in accordance with test method described in Section 3 of SMACNA HVAC Air Duct Leakage Test Manual, except as modified in this Section. Test apparatus shall be in accordance with Section 5 of SMACNA HVAC Air Duct Leakage Test Manual.

F. Test pressure shall be equal to duct pressure class. Negative pressure ductwork shall be tested with negative test pressure.

G. Air leakage shall not exceed limits specified or scheduled. If leakage exceeds allowable limits, identify leaked areas, repair, seal and retest.

H. Provide filter system on duct inlet to test blower. Filter system shall be equal to final filtering efficiency of AHU supply air duct system. Filters are not required for negative pressure testing.

I. Do not insulate ductwork until it has been successfully tested.

J. Maximum permitted leakage (L) in cfm/100 sf duct surface area of each ductwork shall be calculated by:

$L = C_L \times P^{0.65}$

1. P = test pressure (duct pressure class).
2. C_L = duct leakage class, 3 for round/oval ducts and 6 for rectangular ducts and flexible ducts.
3. Total allowable leakage in a duct section:
   = L x (total duct surface area of the section)

K. Welded ductwork shall be air and watertight and shall have no air leakage with allowance stated below.

1. When using test apparatus and procedure described in SMACNA HVAC Air Duct Leakage Test Manual, 1st Edition, Chapter 5 (modified for negative pressure), the following losses can be expected during testing and are acceptable:
   a. 1 cfm per 1” WG of static pressure is allowed for the test equipment and test connections (e.g. 3 cfm when testing at 3” WG.
   b. 0.10 cfm per inch of diameter of temporary caps, regardless of pressure (e.g. 1 cfm for a cap on 10” diameter duct).
2. To the extent possible, walk and observe welded ductwork under test to check for cracked or hissing welds. All leaks in welded sections of ductwork shall be reported to the Laboratory’s Representative and repaired by welding. No caulking or sealing is allowed.

L. Leakage Test for Ductwork Downstream/Upstream of Air Terminal Devices:

1. Representative samples of ductwork (approximately 10% of total linear feet of ductwork) shall require leakage test.
2. Engineer will decide samples of ductwork to be tested and date of leakage test to be conducted.
3. If test results are acceptable to Engineer, remainder of ductwork is permitted to proceed without further testing. If ductwork fails test, repair all ductwork including ductwork not tested. Then repeat leakage tests for new samples of ductwork as described above.

3.9 LOW PRESSURE DUCT CONSTRUCTION (PRESSURE CLASS 2” WG AND UNDER)

A. Use welds, rivets or nuts, and bolts for fabricating ductwork. Fully threaded sheet metal screws may be used on duct hangers, transverse joints and other SMACNA approved locations if screw does not extend more than 1/2” into duct. Sheet metal "TEK" screws 3/4” in length may be used as fasteners in conjunction with factory made transverse joints.

B. Unless otherwise indicated, construct branch take-off fittings as follows:

1. For branch take-offs including branch ducts serving more than one diffuser or grille, use 45° entry fittings. For supply air ducts, expanded or conical taps may be used.
2. For take-offs serving single diffuser, register or grille, use straight spin-in collars with manual balancing dampers.

C. Do not use splitter dampers and/or extractors unless manual volume dampers alone do not accomplish the intended balancing. Obtain Engineer's written approval before installing them. Use of splitter dampers and/or extractors will not eliminate need for specified or indicated manual volume dampers.

3.10 LOW PRESSURE DUCT LININGS

A. All portions of duct designated to receive duct liner shall be completely covered with duct liner. Transverse joints to be neatly butted and there shall be no interruptions or gaps.

B. Duct liner shall be adhered to sheet metal with 90% coverage of adhesive, and all exposed leading edges and all transverse joints shall be coated with adhesive.

C. Duct liner shall be additionally secured with mechanical fasteners, which shall compress duct liner sufficiently to hold it firmly in place. Use weld pins only. Adhesive bonded pins or impact pins are not allowed. Spacing of mechanical fasteners with respect to duct liner interior width shall be in accordance with SMACNA Standard, "HVAC Duct Construction Standards, Metal and Flexible."

D. Apply lining to the following ductwork:
   1. Return ductwork from fan coil units return to return air grille or for a distance of 20 feet from the fan coil unit.
   2. Supply air ductwork from fan coil units discharge to supply air diffusers or for a distance of 20 feet from the fan coil unit.
   3. Ductwork as indicated to be lined
   4. Air transfer ducts

E. Do not apply lining to the following ductwork:
   1. Shower exhaust ductwork
   2. High pressure supply ductwork
   3. Fume hood exhaust ductwork
   4. General Laboratory exhaust ductwork

3.11 HIGH PRESSURE DUCT CONSTRUCTION (PRESSURE CLASS 3” WG AND OVER)

A. Submit construction details including materials, type of service, reinforcing methods, and sealing procedures.

B. Use elbows, tees, laterals, crosses and accessory fittings as shown on drawings and as required to fabricate duct system.

C. Use expanded or conical tees for branch take-offs from mains.

D. Provide manufactured bellmouth fittings at each fan supply air plenum to provide smooth entrance of air into duct system.

E. Provide positive pressure relief doors as indicated on drawings.

F. Provide negative pressure relief doors as indicated on drawings.

G. Construct high pressure ductwork for 6” WG pressure class.

3.12 AIR HANDLING UNIT SYSTEM DUCTWORK PRESSURE CLASS

A. Air Handling Units AHU-1 and AHU-2
   1. Duct pressure class to be as follows:
      a. Outside air intake plenum -2” WG
      b. From air handling unit discharge to inlet of air terminal device (where not in shafts) +6” WG
      c. From air terminal device to diffuser +2” WG

B. General Exhaust Fans EF-1 and EF-2.
   1. Duct pressure class to be as follows:
      a. From exhaust grille to air terminal -2” WG
      b. From exhaust air terminal to fan -6” WG

3.13 FLEXIBLE DUCT

A. Install flexible ducts in accordance with manufacturer's installation instructions and SMACNA Standards, except as modified in this Section of Specifications.

B. In supply air systems without air terminal devices, flexible ducts may be used for final connections to diffusers, grilles, and registers. Flexible ducts shall be of minimum length required to make connections, but shall not be greater than 6 ft in length, unless noted otherwise.

C. In supply air systems with air terminal devices, flexible ducts shall be used for duct connections to diffusers, grilles, and registers for sound attenuation purposes, except above non-accessible ceilings. Flexible ducts shall be minimum 6 ft long and maximum 8 ft long.

D. In return and general exhaust air systems without air terminal devices, flexible ducts may be used for final connections to return grilles and registers and general exhaust grille and registers. Flexible ducts shall be of minimum length required to make connections, but no greater than 6 ft in length, unless noted otherwise.

E. In return and general exhaust air systems with air terminal devices, flexible ducts shall be used for duct connections to grilles and registers for sound attenuation purposed, except above non-accessible ceilings. Flexible ducts shall be minimum 6 ft long and maximum 8 ft long.

F. Centerline radius of bends shall not be less than one duct diameters. FlexFlow Elbow supports by Thermaflex or similar products may be used at diffuser/grille. Connection to assure full radius elbow.

G. Support flexible ductwork at a maximum of 3 ft on center and at elbow, with no portion lying on ceiling supporting system.

H. Individual sections of flexible ductwork shall be of one-piece construction. Splicing of short sections is not allowed.

I. Connect flexible duct liner to collars with draw bands. If collars have beads, position draw bands behind beads.

J. Pull insulation and vapor barrier jacket over liner connection and secure with draw band. For terminations at externally insulated ductwork, fittings, grilles, diffusers, etc., secure flexible duct jacket to ductwork insulation jacket with compatible vapor barrier tape.

K. Flexible ducts are not allowed above non-accessible ceilings.

L. Flexible ducts are not allowed in high pressure ductwork.

M. Flexible ducts are not allowed for special exhaust systems, such as fume hood exhaust, BSC exhaust, shower room exhaust.

N. Flexible ducts are not allowed to pass through any partition, wall, floor or ceiling.

3.14 FUME EXHAUST DUCT CONSTRUCTION

A. General:

1. Construct elbows with centerline radius to width or diameter ratio of at least 1.5 and 45° lateral branch take-offs from mains.

B. Duct pressure class to be as follows:

1. From fume hood, snorkel or biosafety cabinet to exhaust air terminal -4” WG
2. From general exhaust air grille to exhaust air terminal -4” WG

3.	From exhaust air terminal to exhaust main or branch main	-4” WG
4.	Exhaust mains to vertical risers	-4” WG
5.	Vertical risers	-4” WG
6.	From vertical risers to exhaust plenum	-6” WG
7.	Exhaust plenum	-10” WG
8.	From exhaust plenum to exhaust fan	-10” WG
9.	From exhaust fan to exhaust stack	+4” WG

C. Stainless Steel Ducts:
   1. Use 18 ga or heavier 316L stainless steel sheet with all joints and seams butt-welded airtight.
   2. Use longitudinal seam construction with seam at top on horizontal runs. Spiral seams are not allowed on round duct.
   3. Grind and polish smooth all interior joints.

3.15 GENERAL EXHAUST STACKS

A. Construct stacks of no lighter than 12 ga 316L stainless steel sheet. Butt-weld all joints.

B. Construct stacks of sufficient strength so top of stack will not deflect more than 1/2” under horizontal wind pressure of 40 psf over surface area of stack.

C. Provide 3 guy wires connected to stack with stainless steel ring located 1/3 of stack height from top of stack anchored back to building structure.

D. Alternate material shall be Selkirk Metalbestos Model PS positive pressure piping system with 304 stainless steel construction for inner pipe and outer jacket.

3.16 RADIOISOTOPE HOOD EXHAUST

A. For fume hood exhaust from room L043 use 18 ga 316L stainless steel sheet with all joints and seams butt welded air tight. Grind and polish smooth all interior joints so that no crevices remain to accumulate deposits. Dented ductwork will not be accepted.

B. Construction elbows with centerline radius to diameter ratio of at least 1.5.

3.17 BATH OR SHOWER EXHAUST DUCT CONSTRUCTION

A. Use aluminum sheet where indicated on drawings or as specified below, with joints and seams sealed with duct sealant or welded for water tightness.

B. Use aluminum duct for exhaust from bath or shower that contain one shower head. Aluminum duct shall extend from individual exhaust grilles to main exhaust duct. Fabricate exhaust fan discharge ductwork of aluminum or galvanized steel.

C. Weld aluminum exhaust duct for water tightness.

3.18 STERILIZER EXHAUST DUCT CONSTRUCTION

A. Use aluminum duct for exhaust from sterilizer piping spaces when enclosed in separate room and for exhaust located above sterilizer doors. Fabricate all duct work downstream of first location where this occurs to exhaust fan inlet of aluminum construction. Seal or weld aluminum duct air and water tight. Fan discharge duct and other exhaust duct located upstream of point where aluminum duct is required may be of aluminum or galvanized steel construction sealed in accordance with its pressure class.

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SECTION 23 33 14

DUCTWORK SPECIALTIES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 05 95 - Air Systems Test Adjust Balance

B. Section 23 0902 - Control Valves and Dampers (Control and Smoke Dampers)

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements. (Combination Fire/Smoke Dampers only).

1.3 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Capacities
   3. Temperature/pressure ratings
   4. Materials of construction
   5. Dimensions
   6. Manufacturer's installation instructions and/or detailed drawings
   7. All other appropriate data

B. LEED Submittals:
   1. Product Data for IEQ Prerequisite 1: Documentation indicating that duct systems comply with ASHRAE 62.1-2007, Section 5 – “Systems and Equipment”.

1.4 DESIGN CRITERIA

A. Products and materials shall conform to NFPA Section 90A, possessing flame spread rating of not over 25 and smoke developed rating no higher than 50.

B. Ductwork specialties exposed to air stream, such as dampers, turning vanes and access doors, shall be of same material as duct at where the specialties are mounted, unless otherwise noted.

C. Unless otherwise noted, ductwork specialties shall be designed and constructed for pressure class of ductwork in which they are installed.

PART 2 - PRODUCTS

2.1 MANUAL BALANCING DAMPERS

A. Manufacturers: Ruskin, Greenheck, Vent Products or Air Balance, constructed in accordance with SMACNA HVAC Duct Construction Standards, except as modified below.

B. Rectangular Dampers:

1. For low pressure ductwork, for damper blade height up to 12”, use single blade type with minimum 22 ga galvanized steel blade with minimum 3/8” rod for blade width up to 18”, and with minimum 18 ga galvanized steel blade with minimum 1/2” continuous rod for blade width from 19” to 48”. For damper blade height more than 12”, use multiple blade type with minimum 16 ga galvanized steel channel frames, opposed blade linkage operation, with blades minimum 16 ga and 6” to 8” maximum blade width, minimum 1/2” continuous rod and 1/2” x 1/2" galvanized steel angle blade stops. Bearings shall be nylon or molded synthetic. Construct dampers over 48” in width or height in multiple sections with mullions.
2. For high pressure ductwork, dampers shall be constructed to withstand maximum pressure of 5” WG at closed position and maximum velocity of 2000 fpm at open position. Frame and blades shall be constructed of minimum 16 ga with minimum 1/2” diameter or square rod.

C. Single Blade Round Dampers:

1. For low pressure ductwork, damper shall have blade 24 ga, but no less than two gauges more than duct gauge. Rod shall be minimum 3/8” diameter or square continuous. Bearings shall be nylon or molded synthetic.
2. For high pressure ductwork, damper blade shall be minimum 16 ga. Rod shall be minimum 1/2” square continuous and tack welded to blade. Provide sealed end bearing similar to Ventlok #609 and acorn nut type dial regulator similar to Ventlok #635 or 641.

D. Provide damper operators with locking devices and damper position indicators. Sheet metal screws are not allowed in construction or installation of dampers. Use rivets or tack welds.

E. Dampers shall be properly stiffened and fabricated to prevent vibration, flutter or other noise.

F. Extend damper shafts through duct insulation or use elevated regulators for externally insulated ducts to accommodate specified insulation thickness.

G. Segmented Blade (Iris) Dampers:

1. Damper shall be segmented blade (iris) type with 22 ga galvanized steel frame and blades. Casing leakage shall not exceed 6 cfm.
2. Iris blade segments shall be internally linked and driven by manual adjustment knob. Linkage parts shall be fully encapsulated and out of air stream. Manual adjustment knob shall be factory calibrated to the exact aperture position and aligned with the K factor set point to provide linear response flow control.
3. Accuracy of flow measurement shall be ±5%. Assembled units shall be furnished with specific charts designed for exact size and blade aperture configuration. Air pressure taps shall be integral to damper frame and positioned on either side of blade segments.
4. Dampers shall be similar to Ruskin Model VFBD35.

2.2 TURNING VANES

A. Construct turning vanes in accordance with SMACNA HVAC Duct Construction Standards.

B. Square Throat Elbow Turning Vanes (Vane Runner Length up to 18” and Vane Length up to 36”:
   1. Use single thickness vanes having 2” radius and 1-1/2” spacing, 24 ga minimum. Construct vanes in accordance with SMACNA HVAC Duct Construction Standards.

C. Square Throat Elbow Turning Vanes (Vane Runner Length over 18” or Vane Length over 36”:
   1. Use double thickness vanes having 4.5” radius and 3.25” spacing, 24 ga minimum.

D. Radius Elbow Splitter Vanes:
   1. Splitter vanes for radius elbows shall be extended entire length of fitting and constructed in accordance with SMACNA HVAC Duct Construction Standards.

2.3 BACKDRAFT DAMPERS

A. Manufacturers: Air Balance, Inc., American Warming and Ventilating, Louvers and Dampers, Inc., Advanced Air, Vent Products, Greenheck or Ruskin

B. Dampers shall be multi-blade, weighted type with counter-balanced blades and with galvanized steel or aluminum frame equal to Ruskin Type CBD-4. Blade edges to have vinyl gasket or polyurethane foam seals with ball bearings. Dampers to be suitable for flange and gasket connection to ductwork.

2.4 BACKDRAFT DAMPERS

A. Manufacturers: Ruskin or Greenheck

B. Dampers shall be multi-blade, weighted type with counter-balanced blades and with 12 ga galvanized steel frame and extruded aluminum airfoil-shaped blades equal to Ruskin Type CBS 92. Blade edges shall have silicon rubber seals with ball bearings. Dampers shall be suitable for flange and gasket connection to ductwork or fan outlet.

C. Dampers shall be rated to maximum velocity of 4000 fpm, maximum temperature of 250°F and maximum system pressure of 5” WG for damper width of 60” and 14” WG for damper width of 12”.

D. Maximum damper leakage shall be 13.5 cfm/sf based on pressure differential of 1” WG.

E. Use when duct static pressure exceeds 3 “WC.

2.5 FIRE DAMPERS

A. Manufacturers: Air Balance, Prefco, Greenheck, Nailor, Cesco, Pottorff Louvers and Dampers, or Ruskin

B. Fire damper assemblies shall be listed by UL 555 with 165°F fusible link and shall meet construction standards as set forth in NFPA 90A.

C. Fire resistance rating of fire dampers shall be as shown on drawings.

D. Dampers shall be dynamic type dampers rated to minimum 2000 fpm and 4” WG.

E. Dampers shall be curtain type with blades out of air stream when in open position. Where curtain type dampers are not available because of size, use multiple blade type dampers.

F. For round ducts, dampers equal to Ruskin Model FDR25 may be used.

G. Damper fire rating shall be compatible with rating of building surface in which damper is used.

H. Submit UL installation details to showing mounting method and duct connection method.

I. Where ceiling fire dampers are used, they are to be equal to Ruskin CFD(R) 2 or 3, UL Classified for installation in fire rated floor or roof/ceiling assemblies.

2.6 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Ruskin, Air Balance, Prefco, Greenheck, Nailor, Cesco, Pottorff, Louvers and Dampers similar to Ruskin FSD-60

B. Dampers shall meet requirements of NFPA 90A. Dampers shall be 1-1/2 or 3 h rated as shown on drawings, leakage rated at no higher than leakage Class I 4 cfm/ft^2 at 1" WG and 8 cfm/ft^2 at 4" WG under UL 555/555S at temperature category 350°F, and compatible with system static pressures. Furnish dampers with factory-mounted, caulked sleeves and damper operators.

C. Dampers shall use airfoil shaped damper blades. Dampers shall be rated for minimum 4” WG static pressure and 2000 fpm air velocity.

D. For round ducts, dampers equal to Ruskin Model FSDR 25 may be used.

E. Operators shall be 120 V electric powered with auxiliary switch built in for position indication, similar to Ruskin Model MS 4120F2, factory installed outside airstream, linked to dampers for fail closed operation, and be UL Listed and labeled for the application. Operators to be capable of closing damper at pressures encountered in system. Electric operators shall be rated for energized hold open position period of 6 months or more.

F. Dampers shall be furnished with heat sensor set at 165°F.

G. Smoke detector required at each damper will be provided by Electrical Contractor.

H. Submit UL installation details showing mounting method and duct connection method.

2.7 ACCESS DOORS

A. Access doors shall be rectangular, minimum 22 ga frame and minimum 24 ga door, fit air tight with neoprene gasket and shall be suitable for duct pressure class. When access doors are installed in insulated ductwork or equipment provide insulated doors with insulation equivalent to what is provided for adjacent ductwork or equipment. Access doors constructed with sheet metal screw fasteners are not acceptable.

B. Low Pressure Ducts (Pressure Class 2” and Under):
   1. Doors shall be hinged type with sash lock for exposed application and non-hinged type with cam latches for concealed application.
   2. Access doors constructed in accordance with SMACNA HVAC Duct Construction Standard (Figure 7-2) or similar to Ruskin Model ADC or ADH will be acceptable.

C. High Pressure Ducts (Pressure Class 3” and Over):
   1. Use access doors factory fabricated and rated by manufacturer's published literature for installation in systems with pressures to positive or negative 10” WG.
   2. Sandwich access doors made by Ductmate, Ward Industries, or Flexmaster are acceptable, provided that they meet insulation requirements and include edge protection.

2.8 DUCT FLEXIBLE CONNECTIONS

A. Manufacturers: Unless specifically indicated, Ventfabrics, Inc. or Duro Dyne, equal to Duro Dyne model indicated. Material shall be glass fabric, fire retardant, waterproof, air tight and comply with UL Standard 214 and NFPA 90A.

B. General Supply, Return and Exhaust Ductwork:

1. Material for indoor use to be 30 oz per square yard, double coated with neoprene, suitable for -40°F to 200°F continuous operation similar to Duro Dyne Neoprene.

C. Special Exhaust Ductwork:

1. Material for indoor use shall be 17 oz per square yard, teflon or silicon coated, suitable for -65°F to 500°F, similar to Duro Dyne Thermafab.
2. Material for outdoor use shall be combination of inner layer of Thermafab and outer layer of Durolon.

2.9 SOUND ATTENUATING DEVICES

A. Manufacturers: Industrial Acoustics Company, Semco, Vibro-Acoustics or Price

B. Units shall be tested in accordance with ASTM E-477-99 silencer test standard in aero-acoustic test facility which is NVLAP accredited for ASTM E-477-99 Standard. Each test shall have been conducted within last 12 month period. Submit copy of laboratory's NVLAP accreditation certificate on dynamic insertion loss, self-noise power levels, and aerodynamic performance.

C. Outer casing of units shall be not less than 22 ga G90 galvanized steel in accordance with recommendations in the latest edition of ASHRAE Guide and Data Book for high pressure rectangular ductwork for 8” WG or pressure class indicated for duct system, if it is higher than 8” WG. Seams shall be lock formed or continuously welded and mastic filled.

D. Acoustic Materials:

1. Media shall be long fiber fiberglass protected with covering material and lined with not less than 26 ga galvanized perforated steel. Filler and facing material shall meet requirements of NFPA 90A with flame spread rating of 25 or less, and smoke development rating of 50 or less.

E. Covering Materials:

1. Covering material shall be Tedlar film.

F. Ends of attenuators shall be covered at factory with plastic, heavy-duty paper, cardboard, or other appropriate material to prevent entrance of dirt, water, or any other foreign matter to inside of attenuators. Caps shall not be removed until attenuator is installed in duct system.

G. Unless otherwise indicated, sound attenuating devices shall meet acoustical performance requirements as scheduled in each octave band frequency under the flow conditions.

H. Sound Attenuating Devices for Exhaust Air Terminal Units Serving Fume Hood and Snorkel Exhaust:

1. Similar to IAC Model TXL.
2. Tubular type constructed entirely of Type 304 stainless steel, in accordance with recommendations in the latest edition of ASHRAE Guide and Data Book for high pressure rectangular ductwork. Seams shall be lock formed. Units shall contain no sound absorptive material. Attenuation shall be accomplished by controlled impedance membranes and broadly tuned resonators. Units shall not fail structurally when subjected to differential air pressure of 8” WG, inside to outside of casing.

3. Unless otherwise indicated, sound attenuating devices shall meet acoustical performance requirements as scheduled in each octave band frequency under the flow conditions.

I. Sound Attenuating Devices for General Exhaust Air Terminal Units of Laboratory Exhaust Systems:
   1. Similar to IAC Model TXL.
   2. Tubular type constructed entirely of galvanized steel, in accordance with recommendations in the latest edition of ASHRAE Guide and Data Book for high pressure rectangular ductwork. Seams shall be lock formed. Units shall contain no sound absorptive material. Attenuation shall be accomplished by controlled impedance membranes and broadly tuned resonators. Units shall not fail structurally when subjected to differential air pressure of 8” WG, inside to outside of casing.
   3. Unless otherwise indicated, sound attenuating devices shall meet acoustical performance requirements as scheduled in each octave band frequency under the flow conditions.

J. Sound Attenuating Devices for Fume Hood Exhaust Fans:
   1. Similar to IAC Model KM.
   2. Provide units at exhaust fan intakes and discharges as scheduled. Unit length shall be as scheduled.
   3. Rectangular type constructed entirely of Type 304 stainless steel, in accordance with recommendations in the latest edition of ASHRAE Guide and Data Book for high pressure rectangular ductwork. Seams shall be lock formed. Units shall contain no sound absorptive material. Attenuation shall be accomplished by controlled impedance membranes and broadly tuned resonators. Units shall not fail structurally when subjected to differential air pressure of 8" WG inside to outside of casing.

2.10 LOUVERS

A. Manufacturers: Air Balance, Inc., Airolite, Industrial Louvers, Airstream Products Co. Inc., American Warming, Ruskin and Ventilating, Vent Products, Construction Specialties, DOWCO or Louvers and Dampers, Inc.

B. Similar to Airolite Type K638, 12 ga aluminum frame and blades, 45° blades with water baffle, 4” deep, all-welded assembly with color to be white and selected by the architect.

C. Similar to Airolite Type K6776, extruded aluminum alloy not less than 12 ga(0.081” thick, 6063-T52 frame and blades, all-welded assembly, 35° blades with water baffle, 6” deep. Louvers shall bear AMCA certified ratings seal for air performance and water penetration, shall have free area not less than 50% based on 48” x 48” section, and shall have water penetration less than 0.02 oz per square foot under AMCA test at 1300 fpm.

D. Finish shall be white, as selected by the architect, anodized coating minimum thickness 0.0007”.

E. Blank-off panels on unused portion of louver shall be 2” thick insulated panels fabricated of minimum 22 ga galvanized steel on both surfaces. Insulation to be rigid type with minimum R value of 10[(h·ft^2·°F)/(Btu)]. Panels shall be reinforced with minimum 20 ga steel stiffeners.

2.11 BIRD AND INSECT SCREENS

A. Bird screens shall be 1/2” square mesh formed with 0.063” diameter aluminum wire. Insect screen to be 18 x 16 with 0.017” diameter aluminum mesh.

B. Frame shall be removable type of minimum 12 ga, extruded aluminum.

2.12 AIR FLOW MEASURING UNITS

A. Furnished by Control Contractor.

2.13 PRESSURE RELIEF DOORS

A. Similar to Ruskin Model PRD 18, Kees Model BO, or Pottorff Model PPR-B0 for positive pressure and Ruskin Model NRD 18, Kees Model BI, or Pottorff Model NPR-BI for negative pressure applications.

B. Doors and frames shall be 12 ga galvanized steel with seal around door perimeter. Doors shall be double-wall, insulated, when installed in insulated ductwork.

C. Doors shall open automatically to relieve excess pressure above set point and to close when pressure is reduced to less than 3” WG. Setting shall be adjustable from 3” to 8” WG with 1” WG increments in between.

2.14 INSTRUMENT TEST HOLES

A. Manufacturers: Ventlok 699 (up to 1” insulation thickness) or Ventlok 699-2 (over 1” insulation thickness).

B. Use concave gaskets for round ductwork.

2.15 CONTROL DAMPERS

A. Furnished by Control Contractor.

2.16 SMOKE DAMPERS

A. Furnished by Control Contractor.

PART 3 - EXECUTION

3.1 MANUAL BALANCING DAMPERS

A. Install manual balancing dampers in all branch ducts of supply, return and exhaust ductwork, as indicated on drawings and as required to regulate airflow to meet air balance requirements.

B. Install manual balancing damper in branch duct to each diffuser and grille. Install dampers as close as possible to take-offs.

C. Install balancing dampers so as not to flutter or vibrate and as far as possible upstream from the air outlet.

D. Balancing dampers are not required for supply ductwork upstream of air terminal devices.

E. Balancing damper is not required where terminal air device serves a single diffuser or grille.

F. Do not install manual balancing dampers in the following exhaust ductwork:
   1. Fume hood exhaust ductwork.

3.2 TURNING VANES

A. Install turning vanes as shown on drawings and for rectangular square throat elbows unless otherwise indicated. Install turning vanes in accordance with SMACNA Standards and/or manufacturer's recommendations.

B. Turning vanes are not required in transfer air ducts.

C. Install turning vanes so that they are tangent to airflow direction.

3.3 BACKDRAFT DAMPERS

A. Install backdraft dampers where indicated on drawings.

B. Where motorized dampers are shown in exhaust fan discharge duct, or in duct connecting to relief or exhaust louver, backdraft dampers are not required unless specifically indicated. Where motorized dampers are not shown, provide backdraft dampers in these locations.

3.4 FIRE DAMPERS AND COMBINATION FIRE/SMOKE DAMPERS

A. Install dampers where shown on drawings in accordance with manufacturer's installation instructions and requirements of NFPA 90A. Install dampers complete with mounting collars, retaining angles, connections to adjoining ductwork and duct access doors. Install duct access door at each damper with door size large enough to permit replacement of fusible links and resetting of dampers.

B. Test and demonstrate proper operation of each damper after system is installed and ready for operation.
   1. Manually test each damper for proper operation by removing fusible link or actuating EFL or PFL. Repair or replace any damper that does not close completely. Replace fusible link and certify in writing that each damper was installed according to manufacturer's installation instructions and that each damper can be expected to close completely when fusible link melts.
   2. Notify Laboratory and/or Laboratory’s representative at least 48 h prior to testing to allow for witnessing.

C. Contractor shall provide letter from manufacturer's representative indicating that dampers are installed per manufacturer's installation instructions.

D. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

E. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority. Combination Fire/Smoke Dampers only.

3.5 ACCESS DOORS

A. Install access doors where specified, indicated on drawings, and in locations where maintenance, service, cleaning or inspection is required, including automatic dampers, fire dampers, smoke dampers, smoke detectors, fan bearings, heating and cooling coils, reheat coils, humidifiers, filters, bird/insect screens, valves and control devices within duct or casing, at outside air intake duct and at inlet side of turning vanes in return ductwork.

B. Locate access doors for greatest ease of access.

C. Size and quantity of duct access doors shall be sufficient to perform intended service, but not less than the following:

Rectangular Duct Size	Minimum Access Door Quantity and Size
14”and smaller	(1) 8” x 8”
12” to 15” and smaller	(1) 12” x 10”
16” to 21”	(1) 18” x 14”
22” to 27”	(1) 18” x 18”

Rectangular Duct Size	Minimum Access Door Quantity and Size
28” to 47”	(1) 24” x 24”
48” to 96”	(2) 24” x 24”

Round Duct Size	Minimum Access Door Size
10” and smaller	8” x 4”
15” and smaller	12” x 8”

D. Increase duct size to accommodate access door size indicated above where required.

3.6 DUCT FLEXIBLE CONNECTIONS

A. Install duct flexible connections between ductwork and fans or equipment casing containing fans not internally isolated. Installed width shall be suitable for specific application but shall not be less than 4”. Install flexible connections in accordance with SMACNA Standards with double lock or "Grip Loc" connection.

B. Duct flexible connections are not allowed for fan connection serving kitchen hood, dishwasher, or perchloric acid hood.

3.7 SOUND ATTENUATING DEVICES

A. Install sound attenuating devices as indicated on drawings and/or as scheduled.

B. For modular installation of sound attenuators, install galvanized steel holding frame, gaskets, seals, supports and fasteners in accordance with manufacturer's recommendations for multiple unit installation.

3.8 BIRD AND INSECT SCREENS

A. Provide bird screens or insect screens as indicated on drawings at louvers and at intake/exhaust openings.

B. Unless otherwise indicated, provide bird screens where filters are specified and insect screens where filters are not specified.

3.9 AIR MIXING DEVICES

A. Install air mixing devices as indicated on the drawings and/or as scheduled. Install devices and associated duct connection in strict accordance with manufacturer's recommendations.

3.10 AIR FLOW MEASURING UNITS

A. Install where indicated on the drawings and/or as scheduled and in accordance with manufacturer's recommendations.

3.11 FUME EXHAUST FAN SHUTOFF DAMPERS

A. Install in the fan suction ductwork for exhaust fans [XXX] where indicated on the drawings and in accordance with the manufacturer's instructions.

3.12 PRESSURE RELIEF DOORS

A. Install doors vertically where shown on drawings and in accordance with manufacturer's recommendations.

3.13 CONTROL DAMPERS

A. Install dampers in locations indicated on drawings, as detailed and according to manufacturer's instructions.

B. Install blank-off plates or transitions as specified in Control Sections.

C. Provide adequate operating clearance and access to operators.

3.14 SMOKE DAMPERS AND DETECTORS

A. Install smoke dampers in locations indicated on drawings. Allow room for operator installation and access to operator. Install access door in ductwork for access to damper. When damper is installed in location other than in smoke or fire rated wall, use SMACNA seal class A for ductwork between smoke damper and smoke rated wall for affected zone.

B. Smoke detectors will be provided by Electrical Contractor in locations indicated on drawings. Install access door in ductwork for access to detector sampling device.

3.15 INSTRUMENT TEST HOLES

A. Provide instrument test holes at air entering and air leaving side of all internal air handling system components for static pressure differential (Delta P) or temperature differential (Delta T) measurements.

B. Provide ductwork instrument test holes as shown on drawings, or as directed by TAB personnel, or Engineer.

End of Section

SECTION 23 34 00

FANS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 05 13 - Motors

B. Section 20 05 14 - Variable Frequency Drive (VFD) System

C. Section 23 05 50 - Vibration Isolation

D. Section 26 28 16 - Enclosed Switches and Circuit Breakers

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the documents
   3. Capacities/ratings
   4. Fan curves
   5. Materials of construction
   6. Sound power levels
   7. Fan type, size, class, drive arrangement, discharge/rotation, bearings, drives
   8. Wheel type, diameter, rpm, tip speed
   9. Required fan hp including drive losses
   10. Motor data (refer to Section 20 0513 - Motors)
   11. Vibration isolators furnished with fans
   12. Dimensions and weights
   13. Special coatings where applicable
   14. Color selection charts where applicable
   15. Manufacturer's installation instructions
   16. All other appropriate data

B. Fan curves shall include series of curves indicating relationship of flow rate cfm to static or total pressure for various fan speeds, brake hp curves, and selection range (surge curves, maximum rpm, etc).

C. Indicate performance data, based on both design air quantity and 110% of design air quantity.

D. For variable air volume application, indicate operating points at 100, 80, 60 and 40% of design capacity on fan curves including data to indicate effect of variable frequency drives on flow, pressure and hp.

1.4 DESIGN CRITERIA

A. Fan ratings shall be tested and certified in accordance with AMCA Standards 211 and 311 and fans shall bear AMCA Seal.

B. Fans shall be furnished complete with motors, wheels, drive assemblies, bearings and accessories as hereinafter specified. Motors for V-belt drives shall be furnished with adjustable rails or bases.

C. Each fan wheel shall be statically and dynamically balanced to grade G6.3 per ANSI S2.19. Complete fan assembly shall be factory balanced statically and dynamically in accordance with Standard AMCA 204-96 for Balance Quality and Vibration Levels for Fans and meet or exceed guidelines in Application Category BV-3.

D. For fans furnished with 5 hp or larger hp motors, each fan assembly shall have factory run test including vibration signatures taken on each bearing in horizontal, vertical and axial direction. Filter-in reading as measured at fan, scheduled rpm shall not exceed the following values when fan is rigidly mounted.

1. Belt Drive (except Vane Axial) 0.15 in/sec peak velocity
2. Direct Drive 0.08 in/sec peak velocity
3. Written records of run test and vibration test shall be available upon request.

E. Unless otherwise indicated, belt drives shall be V-belt drives selected for 150% of motor nameplate hp.

F. Furnish fans specified with V-belt drives with either variable-pitch or fixed-pitch sheaves for drives 3 hp and smaller and fixed-pitch sheaves for drives 5 hp and larger. Select variable pitch sheaves to drive fan at such speed as to produce specified capacity at approximate midpoint of sheave adjustment.

G. When fixed-pitch sheaves are furnished, system air balancing shall be accomplished by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves. This Contractor shall provide necessary trial and final sheaves and drive belts as required by TAB Contractor.

H. Select each fan to operate at single stable operating point as predicted by fan curve. Fans having 2 potential operating points on fan curves are not acceptable.

I. Provide OSHA Compliant belt and shaft guards for belt driven fans. Provide speed test openings at shaft locations. Paint guards bright yellow.

J. Sound power levels shall be based on tests performed in accordance with AMCA Standards 300 and 301.

K. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled static pressure. Motor furnished with fan shall not operate into motor service factor in any of these cases.

L. Consider drive efficiency in motor selection according to manufacturer's published recommendation, or according to AMCA Publication 203, Appendix L.

M. Where inlet and outlet ductwork at any fan is changed from that shown on drawings, submit scaled layout of change and system effect factor calculations indicating increased static pressure requirements as described in AMCA Publication 201. This Contractor shall be responsible for costs associated with any motor, drive, and/or wiring changes required as a result of duct configuration changes at fan.

N. Exhaust fans serving fume hoods shall be marked with arrows to indicate proper direction of rotation.

O. Unless otherwise scheduled, AMCA Type B spark resistant construction shall be used for fans handling flammable or grease laden vapors. Fans having spark resistant construction shall be electrically grounded so as to prevent static electricity from building up.

P. Fans scheduled with baked phenolic coating shall have internal parts in contact with air stream sand blasted to white metal finish and coated within 24 h. Coating thickness shall be 5 mils minimum, equal to Heresite P-403 (first 3 coats) and L-66L (final 2 coats) with each coat baked separately. Dry film thickness must be verified before final baking. Paint all exterior metal parts with prime coat after metal cleaning and surface preparation. In addition, apply second coat of paint to all exterior surfaces.

PART 2 - PRODUCTS

2.1 PLENUM FANS

A. Manufacturers: Twin City, Greenheck, Chicago Blower, PennBarry or Cook

B. General: Fans shall be airfoil centrifugal type designed for industrial duty and suitable for continuous operation. Fans shall be single width, single inlet, arrangement 3, plenum fans with capacities and operating characteristics as indicated on schedules.

C. Hubs: Hubs shall be cast or welded fabricated hubs with straight bores and keyways. Hubs shall be screwed to the shaft with a minimum of 2 set screws for positive attachment. Hubs using taper lock bushings are not acceptable.

D. Wheels: 12-blade, airfoil type, double skinned and welded to center and wheel sideplates. Fan impeller diameters shall conform to AMCA Standard 99-2401-82. Fan blades shall be designed to provide smooth airflow over all surfaces of blade.

E. Shaft: Fan shafts shall be solid AISI 1040 or 1045 steel. Straight shafts shall be turned, ground and polished to a minimum 16 micro-inch finish. Shaft shall be sized for first critical speed of 200% over the maximum fan operating speed.

F. Bearings: Air handling quality, heavy-duty, grease lubricated, pillow block, self-aligning ball or roller type. Bearings shall be selected for minimum life (ABMA L10) of not less than 80,000 h operation at maximum cataloged operating speed.

G. Inlet Cones: Inlet cones shall be precision spun. Inlet cones shall be aerodynamically matched to wheel side plate to insure full loading of blades. Inlet cones shall be heavy gauge steel.

H. Painting: All metal parts to be painted with prime coat after metal cleaning and surface preparation. In addition, apply second coat of paint to all exterior surfaces.

2.2 INDUCED FLOW FANS (FUME HOOD AND R.I. HOOD LABORATORY EXHAUST)

A. Manufacturers: Greenheck, Strobic Air Corporation, MK Plastics or Cook

B. General: Fans shall be mixed flow type designed for laboratory exhaust duct and suitable for continuous operation. Fans shall be UL/cUL 705 listed. Fans shall be designed for vertical base mount with NEMA premium efficiency, TEFC motors. Furnish fans with AMCA Class C spark resistant construction.

C. Performance ratings: Conform to AMCA Standard 210, 260, and 300. Fans shall be tested in accordance with AMCA 210, 260, and 300 in AMCA accredited laboratory and certified for air and sound performance. Fan shall be licensed to bear AMCA ratings seal for air performance (AMCA 210), sound performance (AMCA 300), and induced flow fan for high plume dilution blowers (AMCA 260).

D. Housings: Fan housing shall be bifurcated allowing drive components, including motor, to be serviced without contact of contaminated air stream. Heavy gauge steel with welded fabrication, adequate reinforcing to prevent housing distortion, fully streamlined inlet cones, multiple straightening vanes following fan wheel to redirect air flow to minimize noise and reduce turbulence and flanged inlet and outlet. Fan housings shall be designed to promote straight line air flow from entrance to discharge. Integral fan housing drain shall be used to drain rainwater when fan is de-energized.

E. Induction Nozzle: Air induction discharge nozzle shall be supplied by fan manufacturer, be integral to fan body design, and be designed to efficiently handle outlet velocity of up to 7000 fpm.

F. Wheels: Wheels shall be mixed flow type with airfoil blades. Blades shall be continuously welded to back plate and wheel cone. Wheels shall be statically and dynamically balanced and complete fan assembly including motor and drive shall be test balanced at or near operating speed at factory prior to shipment.

1. Fan impeller shall include a secondary fan blade located on the impeller back plate to create a negative pressure at the shaft opening.

G. Bearings: Air handling quality, heavy duty, grease packed, cast iron, pillow block type with grease seal, furnished with external grease fittings, selected for minimum life (ABMA L-10) of not less than 40,000 h operation at maximum cataloged operating speed. Bearings shall be fixed to the fan shaft using concentric mounting locking collars.

H. Drives: Provide V-belt drive system rated for 200% of motor nameplate horsepower. Drive shall have minimum of 2 belts.

1. Belt drive motors shall have ventilated weather covers.

I. Shaft: Shaft shall be Type 316 stainless steel, accurately turned, ground, polished, and ring gauged for accuracy. Shafts shall be sized for first critical speed of at least 1.43 times the maximum speed.

J. Access Doors: Bolted and gasketed type in fan housing for inspection of interiors and wheel.

K. Special Coating: All fan components shall have two part electrostatically applied and baked, corrosion resistant coating equivalent of Heresite P-413C. Coating thickness shall be 6 mils (min), not affected by UV, and have superior corrosion resistance to acid, alkali, and solvents. Coating system shall exceed 4000 h ASTM B117 Salt Spray Resistance.

L. Painting: All metal parts not coated with special coating shall be painted with prime coat after metal cleaning and surface preparation. In addition, apply second coat of paint to all exterior surfaces.

M. Provide fan with flow measuring device at inlet cone to fan. Flow measurement device shall not restrict airflow into fan. Measurement device to be factory installed and have an accuracy of +- 3% be provided with a digital display and transmitter with an accuracy of +/- .5% of full scale. Flow measurement device shall be rated for fume hood application.

N. Motor Mounting: Fan motor shall be mounted on adjustable platform appropriate to fan arrangement.

2.3 POWER ROOF EXHAUSTERS

A. Manufacturers: Twin City, Greenheck, PennBarry, Cook, or Carnes

B. Construct housings of spun aluminum.

C. Exhauster wheels shall be centrifugal, non-overloading type with full inlet cones to reduce air turbulence.

D. Provide units with single phase motors with factory mounted and wired NEMA standard disconnect switches.

E. Units shall be listed and bear UL 705 Label.

F. Mount units on factory installed vibration isolators.

G. Furnish units with bird screens.

H. Provide gravity backdraft dampers for fans when control dampers or motorized dampers are not scheduled or specified.

I. Units shall be furnished with factory fabricated, curb and extended base, as required for mounting minimum of 12” above roof.

J. Curbs shall be constructed of galvanized steel or extruded aluminum with continuous welded corner seams, treated wood nailer, minimum 1-1/2” thick, 3 lb density, rigid mineral fiberboard insulation with metal liner.

K. Units to be rated for high wind and meet ASTM-E330.

L. Units shall be furnished with factory fabricated sound curb as indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units as shown on drawings, and according to manufacturer's installation instructions. On units provided with drain connection, install drain valve and cap discharge of drain.

B. Verify lubrication of motor and fan bearings and lubricate properly in accordance with manufacturer’s recommendation and Section 20 0000, Part 3 under LUBRICATION.

C. Perform field mechanical balancing, if necessary, to meet vibration tolerance specified in Section 23 0550 - Vibration Isolation.

D. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

E. Group all air flow measurement displays in one central location in penthouse and mounted at eye level.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

SECTION 23 36 00

AIR TERMINAL DEVICES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 09 01 - Control Systems Integration

B. Section 23 09 93 - Control Sequences

C. Section 23 31 14 - Ductwork (Support)

D. Section 23 33 14 - Ductwork Specialties (Access Doors)

E. Section 23 82 14 - Heating and Cooling Terminal Devices

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the documents
   3. Capacities/ratings
   4. Materials of construction
   5. Sound rating data
   6. Dimensions
   7. All other appropriate data

B. LEED Submittal:
   1. Product Data for IEQ Prerequisite 1: Documentation indicating that units comply with ASHRAE 62.1 – 2010, Section 5 – “Systems and Equipment.”

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70 by qualified testing agency and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1 – 2010, Section 5 – “Systems and Equipment” and Section 7 – “Construction and System Start-Up.”

1.5 DESIGN CRITERIA

A. Where any of air terminal devices are indicated on drawings to control space conditions in conjunction with reheat coil, that reheat coil may be furnished as integral part of or standard accessory to devices specified below. See related work above.

B. When air terminal devices are furnished with reheat coils, either integrally or remotely mounted, control panels of terminal devices shall be mounted on the same side of air terminal device as reheat coil piping connection.

C. Unless otherwise stated, units shall be system pressure independent and maintain air volume within ± 5% of required airflow regardless of system air pressure. Inlet velocity pressure sensor shall be multi-point center averaging type and be capable of amplifying pressure signals.

D. Unless otherwise stated, unit casings shall be constructed of galvanized steel or aluminum meeting SMACNA or ASHRAE Standards, but not lighter than 22 ga.

E. Joints and seams of air terminal devices shall be sealed with appropriate sealant to minimize casing air leakage. Seal joints and seams not factory sealed in field as specified in Part 3.

F. Unit performance shall be certified in accordance with AHRI Standard 880 including sound rating data certified for both casing discharge and radiated sound levels from 125 through 4000 Hz.

G. Supply air units shall be capable of operating from minimum inlet static pressure scheduled to 3” WG.

H. Air valve leakage shall not exceed 1% of maximum inlet rated airflow at 3” WG inlet pressure.

I. Casing leakage rates shall not exceed the following maximum values:

Unit Size	0.5” Ps	1.0” Ps
4, 5, 6	2	3
7, 8	2	3
9, 10	2	3
12	2	3
14	2	3
16	3	4

J. Provide supply air units with internal thermal insulation faced with minimum 0.001” thick aluminum foil. Insulation shall be compressed glass fiber with minimum 3/4” thick, 4 lb/ft^3 density with R-value of 3.5 (h·ft^2·°F)/Btu. Insulation and facing shall meet requirements of UL 181 (Air Erosion, Mold growth and Humidity), and NFPA 90A (Flame 25/Smoke 50) and ASTM C665 (Fungi Resistance). Secure liner with full-seam-length, galvanized steel angles or Z-strips, which enclose and seal all edges. Tape or adhesive will not be acceptable. Liner assembly shall be similar to Titus Steri-Loc.

K. Unit manufacturer or manufacturer's designated representative will be required to verify air terminal device performance and adjust or replace device within warranty period when it is determined that problem exists in area served by device.

L. Room sound levels due to discharge and/or casing radiation from units when operating from minimum pressure scheduled to 2” WG inlet static pressure shall not exceed noise criteria (NC) values in any spaces as

indicated below. If units exceed sound level specified, provide terminal sound attenuators to comply with the noise criteria stated below. Refer to Section 23 3314 - Ductwork Specialties for sound attenuating devices.

Type of Room	Noise Criteria (NC)
All spaces unless otherwise indicated	35
Laboratories and Support Spaces	45
Libraries and Conference Rooms	30

1.6 CONTROLS COORDINATION

A. Unit manufacturer shall provide unit inlet flow sensor, pneumatic tubing and control enclosure for Control Contractor's use.

B. Control Contractor shall furnish all actuators, linkages if required, differential pressure transmitters, controllers and any other devices required for unit control that are not provided by unit manufacturer for unit manufacturer's factory mounting. Unit manufacturer and Control Contractor shall coordinate for proper factory installation.

C. Unit manufacturer shall factory install devices furnished by Control Contractor to result in complete functioning unit. Unit manufacturer shall be responsible for reviewing compatibility of devices furnished by Control Contractor with units being provided.

D. Unit manufacturer shall perform preliminary calibration based on scheduled airflow rates.

PART 2 - PRODUCTS

2.1 VARIABLE VOLUME AIR TERMINAL DEVICES

A. Manufacturers: Titus, Price, Krueger, Enviro-Tec (ETI), Nailor, Carnes, Tuttle and Bailey, Trane, JCI or Carrier

B. Units shall be suitable for 24 V electric control system. Control Contractor shall be responsible for wiring from control panels to each terminal unit.

C. Furnish units with reheat coils having capacities as indicated in schedules.

D. Provide access doors for all air terminal devices with reheat coils at inlet side of coils. Refer to Section 23 3314 - Ductwork Specialties for access doors. Unit manufacturer's standard access doors are acceptable, provided that access doors are appropriately sized and internally lined with same materials as unit casing. If access doors are provided in separate sections as extension of units, these sections shall be internally lined in same manner as units.

2.2 RETURN OR EXHAUST AIR TERMINAL DEVICES (VALVES)

A. Units shall be suitable for 24 V electric control system. Control Contractor shall be responsible for wiring from control panels to each terminal unit. Units shall be similar to Titus Model ECV.

B. Units shall be capable of modulating to full closed position with maximum leakage of 1%.

C. Unit casing shall be minimum 22 ga galvanized steel unless otherwise specified.

D. Casing leakage shall not exceed 3 cfm for inlet sizes 8 and smaller and 5 cfm for inlet sizes 9 and larger at 1.5” WG differential static pressure.

E. Damper shall be heavy gauge steel. Shaft shall be steel with bronze iolite self-lubricating bearings. Damper shall incorporate mechanical stop to prevent overstroking and synthetic seal to limit close-off leakage to 4 cfm at 1.5” WG differential pressure.

F. Unit shall incorporate multi-point, center averaging velocity sensor. Sensor shall provide signal measurable by controller at inlet velocities of 500 fpm. Sensor shall provide control signal accuracy of ±5%, with the same size inlet duct at any inlet condition.

2.3 VENTURI TYPE AIR TERMINAL DEVICES (FUME HOOD EXHAUST AND SNORKEL)

A. Manufacturers: Phoenix Controls

B. Units shall be linearized Venturi type pressure independent.

C. Fume Exhaust Air Valves:
   1. Unit housings, cones and all internal parts exposed to air stream shall be coated with baked Phenolic, equal to Heresite P-403, minimum thickness of 5 mils.
   2. Shafts to be phenolfex coated 316 stainless steel and bushings to be nylon or fiber filled polyester. Spring to be Teflon coated 316 stainless steel wire.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units as shown on drawings and according to manufacturer's installation instructions.

B. Install units with sufficient service space to unit control, actuators and access panels.

C. Seal joints and seams of units not factory sealed to meet allowable leakage rate specified for low pressure ductwork.

D. Provide minimum length of 3 times box inlet diameter of straight rigid duct at box inlet.

E. Provide access doors for terminal devices with reheat coils at inlet side of coils.

F. Provide access panels compatible with ceiling for all units located above non-accessible ceilings.

G. If venturi type air terminal devices are used for supply air application, provide external insulation in accordance with Section 20 0700 - Mechanical System Insulation.

H. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

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SECTION 23 37 13

DIFFUSERS, REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.2 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the Documents
   3. Capacities/ratings
   4. Materials of construction
   5. Sound ratings
   6. Dimensions
   7. Finish
   8. Color selection charts where applicable
   9. Manufacturer's installation instructions
   10. All other appropriate data

1.3 DESIGN CRITERIA

A. Performance data shall be based on tests conducted in accordance with ASHRAE Standard 70.

B. Screw holes on surface shall be counter sunk to accept recessed type screws.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Titus, Price, Carnes, Nailor, Anemostat, or Krueger

B. Acceptable manufacturers for specialty products are listed under each item.

2.2 CEILING DIFFUSERS

A. Diffusers shall be aluminum or steel as scheduled, unless otherwise indicated, and furnished with frame type appropriate to installation. Furnish diffusers with equalizing grids where it is not possible to maintain minimum 2 times duct diameter straight duct into diffuser. Equalizing grids shall consist of individually adjustable vanes designed for equalizing airflow into diffuser neck and providing directional control of airflow.

B. Diffuser models, sizes and finishes shall be as shown on drawings and/or as scheduled. Unless noted otherwise, diffusers shall have baked enamel finish with white color or color selected by Architect.

C. Perforated face ceiling diffusers shall have field adjustable pattern controllers accessible through removable or hinged faceplate. Unless otherwise indicated, furnish diffusers with round neck inlets.

D. Unless otherwise indicated, interior of perforated face diffusers shall be finished in flat black.

2.3 ARCHITECTURAL SQUARE PANEL CEILING DIFFUSERS

A. Architectural square panel ceiling diffusers shall be similar to Titus Model OMNI diffuser.

B. Diffusers shall have one piece 18 ga face panels. Face panel shall be removable by means of four positive locking posts. Exposed surface of face panel shall be smooth, flat, and free of visible fasteners and have rounded off corners. Face panel shall project no more than 3/8” below outside border of diffuser back pan. Back of face panel shall have an aerodynamically shaped, roller edge to ensure tight horizontal discharge pattern.

C. Ceiling diffusers with 24” x 24” full face shall have no less than 18” x 18” face panel size.

D. Back pan shall be one piece die-stamped and shall include integrally drawn round inlet. Diffuser back pan shall be constructed of 22 ga steel. Diffuser neck shall have minimum of 1-1/4” depth available of duct connection. Back pan shape with face panel shall deliver 360° radial horizontal air pattern.

E. Unless otherwise indicated, finish shall be white color.

F. Diffusers shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

2.4 REGISTERS AND GRILLES

A. Registers and grilles shall be aluminum or steel as scheduled unless otherwise indicated, and furnished with frame type appropriate to installation.

B. Supply registers and grilles shall be double deflection type blades to provide for air deflection adjustment in all directions.

C. Return and exhaust registers and grilles shall have fixed blade core.

D. Registers shall be furnished complete with opposed blade volume control dampers, operable from face.

E. Register and grille models, sizes and finishes shall be as shown on drawings and/or as scheduled. Unless noted otherwise, registers and grilles shall have baked enamel finish with color selected by Architect.

F. Interior of perforated face grilles shall be finished in flat black.

G. Back pan to be externally insulated.

2.5 ADJUSTABLE LINEAR DIFFUSERS

A. Linear diffusers shall be extruded aluminum and furnished with frame type appropriate to installation with diffuser elements being removable from frame. Diffuser vanes shall provide both air pattern and flow rate adjustment with air pattern having full 180° adjustment. Diffuser vanes of single slot shall be segmented on 2 ft or 3 ft centers.

B. Diffuser models, lengths and slot sizes shall be as shown on drawings and/or as scheduled. Unless otherwise indicated, frame face shall have baked enamel finish with color selected by Architect. Diffuser vanes and frame interior shall be finished in flat black.

C. Plenum to be insulated.

2.6 FIXED BLADE LINEAR DIFFUSERS AND GRILLES

A. Linear diffusers and grilles to be extruded aluminum with frame type appropriate to sidewall, sill or ceiling installation as indicated.

B. Diffuser and grille models, lengths, blade spacing and blankoff strips to be as shown on drawings and/or as scheduled.

C. Diffusers used for supply air to be furnished with straightening or equalizing vanes. Blades to be fixed at 0 or 15° deflection as scheduled.

D. Unless otherwise indicated, diffusers and grilles to have anodized aluminum finish with color selected by Architect.

E. Plenum to be insulated.

2.7 WIRE MESH GRILLES OR SCREENS

A. Grilles shall be 2 X 2 mesh 1/2” galvanized steel or aluminum hardware cloth in spot welded galvanized steel frame with 1-1/2” width.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install grilles, registers and diffusers as shown on drawings and according to manufacturer's instructions.

B. Unless otherwise indicated, size ductwork drops to diffusers or grilles to match unit collar sizes.

C. Seal connections between ductwork drops and diffusers/registers/grilles air tight.

D. Unless otherwise shown, provide wire mesh screen at end of each open ended duct (OED) that is exposed in occupied spaces.

E. Blank off unused portion of linear diffusers and grilles.

F. Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, paint inside of duct with flat black paint to reduce visibility.

G. Protect diffusers, registers and grilles from construction dirt. Clean or replace those soiled or stained prior to turnover to Laboratory.

End of Section

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SECTION 23 41 14

FILTERS

PART 1 - GENERAL

1.1 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.2 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the Documents
   3. Capacities/ratings; cfm, area, face velocity
   4. Efficiencies and initial/final pressure drop
   5. Materials of construction
   6. Dimensions
   7. Filter gauges data
   8. Manufacturer's installation instructions
   9. All other appropriate data

B. LEED Submittals:
   1. Product Data for IEQ Prerequisite 1: Documentation indicating that units comply with ASHRAE 62.1-2007 Section 5 – “Systems and Equipment”.
   2. Product Data for IEQ Credit 4.1: For adhesives and sealants, including printed statement of VOC content.

1.3 DESIGN CRITERIA

A. Filters shall have UL, Class I or Class II Listing.

B. Holding frames or housings specified in this Section may be furnished by filter manufacturers listed below, or where applicable, as part of factory packaged air handling units.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. American Air Filter, Camfil/Farr, Flanders Precisionaire, Glasfloss, Airguard or Filtration Group unless otherwise noted under individual filter.

2.2 DISPOSABLE PANEL FILTERS

A. Similar to Farr 30/30 or Flanders Precisionaire PrePleat 40.

B. Media shall be non-woven, fine fibered material laminated to rigid backing to hold pleat formation, having minimum efficiency MERV 8 based on ASHRAE Test Standard 52.2 (average efficiency of 30% based on ASHRAE Test Standard 52.1).

C. Filter housing shall consist of air handling or cabinet fan unit manufacturer's low velocity filter section, or holding frame, as scheduled. When holding frame is indicated, it may be furnished by filter manufacturer or it may be contractor fabricated.

D. Filters shall be 2” thick of size and capacity as scheduled. Clean filter pressure drop shall not exceed 0.31” WG based on 500 fpm face velocity.

2.3 DISPOSABLE RIGID CARTRIDGE TYPE AIR FILTERS

A. Similar to Farr E-Series RIGA-FLO or Flanders Precisionaire

B. High performance deep pleated, rigid, disposable type filters. Each filter shall consist of high efficiency media, enclosing frame, contour stabilizers on both air entering and exiting sides and support grilles. Filters shall be designed to withstand minimum differential pressure of 6” WG without structural damage to filter frame, seals or media.

C. Filter thickness, size and capacity shall be as scheduled.

D. Filters shall have minimum efficiency MERV 13 based on ASHRAE Test Standard 52.2 (average efficiency of 80-90% based on ASHRAE Test Standard 52.1). Initial resistance at 500 fpm face velocity shall not exceed 0.50” WG.

2.4 FILTER HOLDING FRAMES

A. Frames shall be minimum 16 ga galvanized steel construction with provisions for assembly in a bank. Frames shall be suitable for filters scheduled and incorporate gaskets and spring clips to prevent air bypass.

2.5 FILTER PRESSURE DROP GAUGES

A. Dwyer Series 2000 Magnehelic pressure gauge.

B. Unless otherwise indicated below, select scale range to be most appropriate to clean and dirty filter pressure drops.

Filter Type	Scale Range ” WG)
Throwaway filters	0-0.5
Filters with 25 to 30% efficiency based on atmospheric dust spot test	0-1.0
Filters with 31 to 99% efficiency based on atmospheric dust spot	0-2.0

C. Provide gauges for each filter bank, including gauges across each individual filter bank in built-up rack assemblies, suitable for flush mounting in a panel, including air filter gauge accessory package for use with 1/4” OD copper tubing.

D. Provide 3/4” spacer at one 2’ x 2’ filter section between filter elements in built-up rack, adjacent to unit wall for placement of intermediate pressure probe.

2.6 ADDITIONAL FILTER MEDIA

A. For disposable panel filters, enough media for 3 filter changes, shall be provided for each air handler. Media used during construction shall be replaced before building flush out and when system is air balanced. If additional filters are required during construction they shall be provided by installing contractor. Third set of media not used shall be turned over to Laboratory as spare.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filters as shown on drawings and according to manufacturer's instructions.

B. Provide supports as required and necessary clearance for changing filters.

C. Provide structural supports, outside casing and blank-off materials for all field assembled filter banks, and filter banks where housings are not furnished by filter manufacturer.

3.2 FILTER PRESSURE DROP GAUGES

A. Mount gauge near each filter bank and install static pressure sensors according to manufacturer's instructions.

B. Mount gauge on control panel.

3.3 FILTER HOLDING FRAMES

A. Provide frames for all filter banks as required. Install built-up filter banks in accordance with manufacturer's installation instructions.

End of Section

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SECTION 23 72 14

HEAT RECOVERY EQUIPMENT

PART 1 - GENERAL

1.1 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.2 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Capacities/ratings/efficiencies
   3. Pressure/temperature rating
   4. Materials of construction
   5. Dimensions and weights
   6. All other appropriate data

1.3 CHECK, TEST AND START

A. Rotary type heat exchanger manufacturer shall provide services of factory trained service engineer to supervise installation and start-up of heat exchangers, and to field measure purge air quantity, seal leakage and heat transfer efficiency. Service engineer shall also instruct Laboratory's representative in operation and maintenance of unit. Before acceptance by Laboratory, unit manufacturer's representative shall approve, and certify in writing, the complete installation including ductwork, wiring connections and proper functioning of all operational controls, and unit performance including heat transfer efficiency and air leakage quantities. Start-up shall not be performed until start-up date has been approved by Architect/Engineer.

1.4 WARRANTY

A. Standard warranty to cover material and labor and warranty shall be provided covering all materials supplied and installed by wheel manufacturer for a period of 5 years.

B. In addition to standard warranty, provide factory trained service personnel one year after start-up heat recovery equipment to verify specified heat transfer efficiencies and specified quantities of purge and seal leakage.

PART 2 - PRODUCTS

2.1 AIR-TO-AIR HEAT EXCHANGERS (ROTARY TYPE)

A. General:
   1. Manufacturers: Semco, Thermotech, SG America or approved equal
   2. Unit capacities, efficiencies and operating characteristics shall be as scheduled.

3. Units shall be complete with energy transfer wheels, permanently lubricated bearings, shafts, purge sectors, air-seals, wheel drive motors, motor speed reducers, drive belts, all enclosed in steel casing. Units shall be factory assembled, tested and shipped as one piece.
4. Unit shall be capable of transferring sensible and latent heat at approximately the same efficiencies and be tested in accordance with ASHRAE 87-78P.
5. Structural frame and casing shall have a maximum deflection of 1/32 inch measured at the outer radius at maximum rated airflow condition and static pressure.
6. External tapered roller bearings shall be provided and sized for a minimum L-10 life of 1,000,000 hours of operation and shall be changeable without a complete disassembly of the rotor. Shaft journals shall be machined to proper tolerance as specified by the bearing manufacturer. Shaft shall be machined as to provide a shoulder against the bearings for a positive locked position to eliminate any lateral movement of the rotor due to axial bearing loads. Grease fittings shall be easily accessible.

B. Transfer Media:

1. Construct transfer media of non-asbestos material and in accordance with NFPA ruling, pass UL 900 flame and smoke tests.
2. Design transfer media for laminar airflow and capability of passing solids up to 300 microns.
3. Transfer media shall, when exchanging energy at efficiency listed in schedule, run dry to touch and not require condensate drain for summer or winter operation.
4. Rotor media shall be made of aluminum, which is coated to prohibit corrosion. Media surfaces shall be coated with non-migrating solid absorbent layer prior to being formed to insure that all surfaces are coated and that adequate latent capacity is provided.
5. Construct rotor of corrugated aluminum treated with inorganic compounds and strengthened with radial spokes for rigidity. Desiccant coating shall be bacteriostatic, non-toxic and non-corrosive. Desiccant carryover shall be limited by coating surface of the aluminum wheel with a polymer coating.
6. Desiccant shall utilize a 3A molecular sieve certified by manufacturer to have internal pore diameter distribution which limits absorption to materials not larger than critical diameter of water molecule, 4.0 angstroms. Rotor media shall be supplied with acid resistant face coating to prevent corrosion.
7. Rotor media shall be provided in segments to allow for field erection or replacement of one section of media at a time without side access. No external pullers or other special tooling shall be required for field assembly or replacement. Medial shall be machined to fit in between primary and secondary spoke and guiding flange of outside rim. Each media segment shall be compressed independently of other segments during manufacturing without causing any angular deformation and resulting misfits between spokes and media parts. Results shall be wheel with flatness of ± 1/32”. No adhesive or silicone shall be necessary to secure media in place.
8. Spokes shall be made of extruded aluminum with a maximum deflection of 1/32 inch at maximum rated airflow and static pressure.

C. Purge and Seals:

1. Furnish units with built-in purge sections, allowing maximum cross contamination of particulates of 0.2% and maximum exhaust air carryover of 0.04% by volume.
2. Provide casing seals on periphery of rotor, as well as on duct divider and purge section.
3. Seals shall be adjustable and constructed on neoprene, held in place with clips fastened to stud welded bolts and compressed by retaining band. Required seal clearance shall be factory set and checked at installation.
4. Rotor seal shall be Labyrinth non-contact seals. Multi-pass seal shall utilize 4 labyrinth stages for optimum performance. Seal system shall be able to withstand pressure differential up to 12” WG without deflecting or causing excessive air leakage. Seals shall be adjustable and set within 0.05” of rotor surface.

D. Drive Assembly and Controls:
   1. Units shall be capable of variable speed operation to maintain constant design or scheduled supply air discharge temperature.
   2. Manufacturer shall furnish units with all components necessary for control of variable speed operation including variable speed motor and drive assembly, SCR controls, air stream thermostat for heating control, summer-winter changeover thermostat and control panels suitable for remote mounting.
   3. Provide interface such as Modbus, Bacnet to BAS.
   4. Control System shall include four linearized thermistor sensors as follows:
      a. Proportional temperature controller mounted in supply air stream.
      b. Differential summer/winter changeover sensors mounted in outdoor and return air streams.
      c. Frost prevention sensor located in the exhaust air stream.
      d. Digital readout of the temperature reading recorded by these sensors and control setpoints.
   5. External tapered roller bearings with double set screw locking collars shall be provided and sized for a minimum L-10 life of 219,000 h of operation, and shall be changeable without complete disassembly of the rotor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units as shown on drawings, and in accordance with manufacturer's installation instruction.

B. Install Dwyer Series 2000 magnehelic pressure gauge across unit in supply air stream.

C. Install thermometer at each side of unit in both supply and exhaust.

D. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 AIR-TO-AIR HEAT EXCHANGERS (ROTARY TYPE)

A. When installed in field erected, assembly, provide solid air separation between the 2 air streams so that air leakage does not occur through casing. Adjust seals to recommended clearance before operating fans for any purpose.

3.3 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

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SECTION 23 73 23

FACTORY FABRICATED CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 05 13 - Motors

B. Section 20 05 14 - Variable Frequency Drive (VFD) System

C. Section 20 05 29 - Mechanical Supporting Devices

D. Section 20 07 00 - Mechanical Systems Insulation

E. Section 23 05 50 - Vibration Isolation

F. Section 23 09 01 - Control Systems Integration

G. Section 23 09 02 - Control Valves and Dampers

H. Section 23 09 93 - Control Sequences

I. Section 23 21 16 - Pipe and Pipe Fittings

J. Section 23 21 18 - Valves

K. Section 23 21 20 - Piping Specialties

L. Section 23 33 14 - Ductwork Specialties

M. Section 23 34 00 - Fans

N. Section 23 41 14 - Filters

O. Section 23 82 16 - Coils

P. Section 23 84 13 - Humidification Equipment

Q. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables

R. Section 26 05 33 - Raceway and Boxes for Electrical Systems

S. Section 26 27 26 - Wiring Devices

T. Section 26 28 16 - Enclosed Switches and Circuit Breakers

U. Section 26 29 13 - Enclosed Controllers.

V. Section 26 51 00 - Interior Lighting

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplemental Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 SUBMITTALS

A. Shop Drawings for all equipment including, but not limited to, the following:
1. Appropriate identification
2. Complete drawings showing plans and sections including details of construction
3. Overall unit dimensions and individual components and sections dimensions
4. Shipping and operating weight of unit and/or sections
5. Structural design load
6. Details of component support
7. Capacities/ratings
8. Materials of construction
9. Thermal and acoustical performance of wall, roof and floor panels
10. Pressure ratings and leakage ratings
11. Thermal break construction details and performance calculations or test data
12. Each component manufacturer's name, model number and data. (Refer to each component section for submittal requirements.)
13. Air leakage rates and test data
14. Wiring diagrams and terminal points for control panels provided with units
15. Manufacturer’s installation instructions
16. Air handling unit manufacturer’s local representative and phone number

1.4 DESIGN CRITERIA

A. For housings and floors operating under positive pressure (fan discharge side), maximum allowable deflection shall not exceed 1/200th of any span in any direction at ± 10” WG.

B. For housings and floors operating under negative pressure (fan inlet side), maximum allowable deflections shall not exceed 1/200th of any span in any direction at ± 10” WG.

C. Air handling unit manufacturer shall install all equipment furnished by others and provide all other equipment as specified to result in complete and operational unit. Unit manufacturer shall assume single source responsibility for all air handling unit components and accessories.

D. Furnish units complete with fans, back draft dampers, piping, valves, piping specialties, actuators, motors, coils, humidifiers, drain pans, filter sections, damper sections and interior lighting, meeting configuration and as shown on drawings, specified and scheduled. All unit components shall meet this Section of Specification and all requirements specified in each section and division listed under Related Work. Supply and exhaust enthalpy wheel control dampers shall be provided by unit manufacturer. Isolation, outside air and exhaust air control dampers and actuators will be furnished by Control Contractor for factory mounting by unit manufacturer.

E. All materials as applied shall meet NFPA 90A possessing flame spread rating of not over 25 and smoke developed rating of not over 50.

F. Unless otherwise indicated, galvanized steel shall be G90 according to ASTM A924 (formerly ASTM A525), A653 and ASTM A-90 and aluminum sheet shall be 3003-H14 alloy, conforming ASTM B209.

G. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled static pressure without operating into motor service factor.

H. Motor furnished with fan shall not operate into motor service factor in any cases.

I. Where inlet and outlet ductwork at any fan is changed from that shown on drawings, submit scaled layout of the change and system effect factor calculations, indicating increased static pressure requirement as described in AMCA Publication 201. This Contractor shall be responsible for any motor drive and/or wiring changes required as result of duct configuration changes at fan.

J. Air handling unit static pressure to take into consideration actual static pressure loss of components furnished within unit.

K. Wire brush all welds with solvent and wipe clean all bare metal before painting.

1.5 FINAL CLEANING

A. Outside and inside of each air handling unit shall be thoroughly cleaned. Use industrial grade cleaners to remove construction dust, sheet metal mill finish or grease. Unit openings shall then be covered with sheet metal or other proper material until ductwork is connected.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Trane Custom, Climate Craft, Governair and Ingenia Technologies Inc. with operating characteristics as scheduled and physical dimensions as shown on drawings and/or detailed.

2.2 UNIT BASE

A. Unit base shall be fabricated from structural steel or fabricated steel.

B. Base shall be sized to provide sufficient height above floor to accommodate cooling coil drain trap height indicated on details. Additional steel base may be used as sub-base to provide the required trap height. Sub-base may be provided at factory by unit manufacturer or provided at field by Installing Contractor.

C. Weld steel solid at connection points to assure rigidity. Size perimeter steel to allow for rigging and handling.

D. Locate and size base cross supports to support internal components.

E. Add lifting lugs to perimeter steel along the longest length of unit or unit module. Incorporate means of attaching cable or chain into each lug.

F. Lifting lugs shall be removable after placement of equipment.

G. Base shall be split in maximum size pieces to allow for economical shipment to jobsite and placement within building. Provide bolting structural steel on both sides of split for field joining.

H. Unit base shall be primed and finished with rust inhibiting epoxy paint.

2.3 UNIT FLOOR

A. Unit floor shall be constructed to meet the maximum allowable deflection, but constructed of no lighter than:
   1. 16 ga plate of galvanized steel with anti-slip epoxy paint.

B. Floor joints and seams shall be sealed to meet allowable housing leakage rate specified. Use acrylic latex sealant meeting ASTM C834-76 (1981) or polyurethane sealant, ASTM C-920, Type S, Grade NS, Class 25, USDA Approved.

C. Provide recessed drain pans as integral part of unit floor in cooling coils, heating coils section. Entire floor including base drain pans shall be insulated on underside to have same thermal and acoustical performance specified for unit housing. Insulation shall be supported by minimum 20 ga galvanized steel liner with joints sealed to provide continuous vapor barrier.

1. Drain pans shall be constructed from minimum 16 ga 304 SS sheet.
2. Drain pan shall be double sloped; pitched down in direction of air flow and pitched sideways to drain connection.
3. Locate drain connections at lowest point of pan, one on either end. Connections shall extend through perimeter base channel and be continuously welded to insure air-tight seal as well as eliminate requirement for backup wrench during field piping. Provide removable cap on each drain connection.

2.4 UNIT HOUSING

A. Unit housing shall be constructed of minimum 2” thick double wall panels meeting thermal, acoustical and structural requirements specified.

B. Panels shall utilize modular panel type construction. Panels may be self-supporting with internal support structure or supported by structural frame work.

C. Panel joints and seams shall be sealed with proper gasket and caulking to meet allowable housing leakage rate specified.

D. Outer face of panels shall be constructed of no lighter than 16 ga galvanized steel and solid inner face of panels shall be constructed of no lighter than 20 ga G90 galvanized steel.

E. Unit casing shall be insulated with minimum 3 pcf density glass fiber insulation. Composite panel shall have heat transfer factor not greater than 0.12 $Btu/h \cdot ft^2 \cdot °F$.

F. Perforated Inner Face of Panels (Acoustical Absorptive Panels):

1. Acoustical absorptive panels shall have perforated inner face constructed of no lighter than 22 ga galvanized steel with fibrous inert core.
2. Panel core material shall be minimum 3 pcf density fibrous inert insulation and panel shall have heat transfer factor not greater than 0.12 $Btu/h \cdot ft^2 \cdot °F$.
3. Provide acoustical-thermal fill containment material of glass fiber cloth or Mylar with minimum 1 mil thickness. Provide acoustic stand-off layer between perforated liner and core material.

G. Use solid inner surface for all sections except fan inlet and discharge sections where perforated inner face to be used.

H. Provide blank-off panels with proper gaskets and sealants to prevent air bypass around equipment such as filters, coils, humidifiers and sound attenuators. Blank-off panels shall be constructed of galvanized steel no lighter than 16 ga unless otherwise noted. Blank-off panels at cooling coil sections shall be insulated with 3/4” thick insulation similar to AP Armaflex SA Duct Liner. Do not insulate blank-off panels between cooling coils located above drain pans.

I. Panel Sound Transmission Loss in accordance with ASTM E90 shall equal or exceed the following:

	Octave Band Center Frequency (Hz)					
	125	250	500	1000	2000	4000
Transmission Loss (dB)	19	23	33	43	52	57

2.5 ACCESS DOORS

A. Each unit section shall have minimum 20” x 72” access door, unless otherwise specified or shown differently on drawings. Access doors for filter and coil sections shall be minimum 24” x 72”.

B. Fan section access door shall be sized to allow removal of fan wheel and motor through door, but not smaller than 30” x 72”. If access door needs to be wider than 36”, removable access panel may be provided.

C. Access doors and door frames shall have similar thermal break construction as specified under Unit Housing.

D. Access doors shall be same construction as housing panels.

E. Access doors shall be guaranteed tight closing through use of seals around entire periphery. Provide neoprene gasket between door frame and housing for air tight seal.

F. Each access door shall be furnished with corrosion resistant metal hinges or continuous piano hinge and shall have at least 2 stainless steel or aluminum alloy handles operable from either side.

G. Doors shall open against higher air pressure to affect seal.

2.6 REMOVABLE ACCESS PANELS

A. Removable access panels shall be provided as indicated on drawings and where equipment removal is not possible through access door. Removable panels shall be same construction as housing panels.

2.7 FILTER SECTIONS

A. Filters shall be provided as specified and scheduled. Holding frames shall be installed by unit manufacturer to raise filters off floor and to prevent leakage as specified by unit manufacturer.

2.8 HEAT RECOVERY SECTION

A. Provide heat recovery wheel as specified and indicated on drawings. See specification 23 7214.

B. Provide air sampling test ports on both sides of the wheel for the supply and exhaust air stream.

2.9 HEATING COIL SECTION

A. Provide heating coils, piping and internal piping as specified and indicated on drawings.

B. Terminate piping outside of unit casing for connection by Mechanical Contractor. Provide necessary pipe supports and hangers.

C. Each coil shall be supported by galvanized steel frame which is independent of unit casing. Support frame shall allow individual coil removal. Coils shall be removable through unit access doors. Blank-off panels shall be galvanized steel sheets with insulation as specified.

2.10 COOLING COIL SECTIONS

A. Provide cooling coils, piping and piping specialties specified, and indicated on drawings.

B. Terminate piping outside of unit casing for connection by Mechanical Contractor. Provide necessary pipe supports and hangers.

C. Each coil shall be supported by 304 stainless steel frame which is independent of unit casing. Support frame shall allow individual coil removal. Coils shall be removable through unit access doors or removable access panels. Blank-off panels shall be 304 stainless steel sheet with insulation as specified.

D. Each coil support shall include minimum 16 ga 304 stainless steel all welded condensate drain pan extending minimum 6", but no more than 12" downstream of coil face. Each drain pan shall have sufficient depth to hold condensate water but not less than 2". Drain pan shall be sloped in 2 directions (pitched down in direction of airflow and pitched sideways to drain connection) for self-drainage at minimum 1/4" per foot slope. Drain pan shall be individually piped down to drain pan located below, and bottom drain pan to be piped to hub drain at exterior of unit. Drain connection opening shall be flush with bottom of pan. Side pan connection located at lowest point of pain may be used only where bottom pan connection cannot be used. Drain pipe shall be 304 stainless steel with sufficient size, but not less than 1-1/2".

E. Instead of drain pan under bottom coil, recessed pan, integral with unit floor may be used. It shall be constructed as specified above including thermal insulation and drain lines, and shall incorporate required drain trap height.

2.11 FAN SECTION

A. Fan array and motors for supply and exhaust shall be provided as scheduled and meet requirements of appropriate specification sections, tested in accordance with AMCA requirements. Each fan is to be provided with back draft damper with pressure drop of .08" WC or less.

B. Fan array systems shall include multiple, direct drive plenum fans constructed per AMCA class III.

C. Individual fan assemblies shall be removable through 30" wide access door or removable panel.

D. Fan and motor shall be factory mounted on vibration isolation equipment meeting requirements of Section 23 0550 - Vibration Isolation. Vibration base shall include integral adjustable motor base.

2.12 HUMIDIFIER SECTION

A. Provide humidifiers, piping and supports as specified, and indicated on drawings. Terminate piping outside of unit casing for connection by Mechanical Contractor.

B. Size and locate humidifier distribution tubes to receive uniform air flow on entire tube.

C. Provide required absorption distance between humidifier and downstream equipment or housing wall.

2.13 DISCHARGE AIR SECTION

A. Provide with framed discharge opening or spun bellmouth fitting conforming to size and configuration of the ductwork.

2.14 FLOOR OPENING PROTECTION

A. Floor openings shall have safety grates using 1" x 1/8" steel bar stock on 1-1/4" center spacing. Grates shall have same finish as floor. Provide 1-1/2" lip of galvanized steel at entire perimeter of opening.

2.15 CONTROLS

A. Control devices shall be by same manufacturer providing control devices for the remainder of the building.

B. Dampers shall be provided per specification 23 0902.

C. Control devices, will be furnished by Control Contractor and shall be factory installed by unit manufacturer as shown on plans and as described in control section of specifications or installed in field per unit manufacturers requirements to maintain construction quality of the air handling unit.

2.16 TESTING

A. Unit manufacturer shall provide factory tests to verify casing leakage after units are assembled.

B. Unit manufacturer and installing contractor shall jointly provide field tests to verify casing leakage after units are installed at jobsite. Coordinate with Electrical Contractor for power to unit test fan.

C. Casing leakage tests shall verify that unit casing leakage is less than 1% of design air flow at +-10" WG static pressure.

2.17 ELECTRICAL SERVICE

A. Provide adequate lighting and switching so equipment can be observed and maintained in safe manner. Combination lighting and convenience outlet circuit is required for each section of unit. Each access section shall contain a minimum of one light fixture. Sections wider than 12 ft shall have multiple light fixtures with maximum spacing of 6 ft.

B. Lights shall be 120 Volt vapor-proof fluorescent type. Fluorescent tubes shall be T8 type approved by electrical engineer

C. Lights, switches, convenience outlets, wiring and conduit shall meet requirements of appropriate specification sections of Division 26.
   1. Provide one central light switch with pilot light for all sections. Locate switch near power connection point.
   2. Provide timer for light switch to automatically turn off lights after preset time. Timer shall be similar to Intermatic Model FF2H with 0-2 h range and hold feature to override automatic shut-off function.

D. Each fan motor shall be individually wired to a motor control panel containing motor overloads and VFD. Electrical panel shall be factory mounted and wired.
   1. Single VFD with Bypass size for the entire fan array.
   2. Each thermal overload shall be equipped with an auxiliary contract. Provide single point dry contact for alarm.
   3. Electrical panel shall be provided with indicator lights for each individual motor to indicate operating status.

E. Each control panel shall have single point electrical power connections. Therefore, units with supply and exhaust fan wall would have two power connections.

F. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards and local code requirements.

G. The factory wiring performed by the air handler manufacturer may need to be disconnected to facilitate shipment and installation. It shall be the responsibility of the installing contractor to reconnect any wiring as needed in the field.

H. Provide internal ground fault protection such that a ground fault in any of the motor circuits does not cause a system shutdown.

I. Wiring and conduit inside of unit shall be provided by unit manufacturer meeting requirements of appropriate Specification Sections of Division 26. Wiring in unit shall be in metal conduit.

1. Provide junction box for each fan array motor at outside of unit wall for 3 Ph, 480 V power connection and separate junction box for 1 Ph, 120 V power connection.

2.18 PIPED SERVICE

A. Interior piping and equipment installation shall be complete. Piping shall be installed and tested per appropriate specification section. Unit manufacturer shall be responsible for any leaks, which occur in unit during system testing which occurs before system startup.

B. Extend piping for each coil and humidifier if used through panel casing. Terminate piping with flange for pipe 2-1/2" and larger or threaded connection for pipe 2” and smaller with caps.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Units shall be assembled in modules in unit manufacturer's plant to allow for testing of complete unit.

B. Unit manufacturer shall supervise and be responsible for all field joining of the modules, including sheet metal, electrical and piping. Local trades may provide labor for unit assembly and installation.

C. Joints in floor between modules shall be air and water tight.

D. Unit manufacturer shall provide and install all equipment within unit as specified including fans, motors, coils, humidifiers, dampers, sound attenuating devices, piping, piping specialties, ductwork specialties, lights, switches and all equipment necessary to complete air handling equipment contained within housings. Mechanical and electrical connections (i.e., piping and conduit) shall be stubbed through housing so that appropriate contractor may provide service to air handling unit. Electrical wiring and control wiring shall terminate in junction boxes on accessible side of unit.

E. Provide structural steel sub-base as required. Refer to Unit Base in Part 2.

F. Field mounting of any equipment on housing walls or roof is not allowed without prior approval of Engineer.

G. Unit manufacturer and Installing Contractor shall coordinate with other trade Contractors, all necessary requirements to assure proper air handling unit installation.

H. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 PROTECTION OF OPENINGS

A. Protect openings on housings during construction against entry of foreign matter and construction dirt.

3.3 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

B. Unit manufacturer and Installing Contractor shall jointly perform field casing leakage tests on each completed housing assembly as previously specified and shall be responsible for repair of all leaks. Submit certified test data to Engineer for approval.

End of Section

SECTION 23 82 14

HEATING AND COOLING TERMINAL DEVICES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 05 13 - Motors

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 SUBMITTALS

A. Shop Drawings for all items in this Section including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the documents
   3. Capacities/ratings
   4. Materials of construction
   5. Dimensions and weights
   6. Color selection chart where applicable
   7. Wiring diagrams
   8. Motor data (refer to Section 20 0513 - Motors)
   9. For chilled beams, submit performance data from independent testing agency. Performance data to include cooling capacity at supply water temperatures scheduled, air pressure drop, sound data, and water pressure drop for each beam length.
   10. All other appropriate data

B. LEED Submittal:
   1. Product Data for IEQ Prerequisite 1: Documentation indicating that units comply with ASHRAE 62.1-2007, Section 5 – “Systems and Equipment.”

1.4 REFERENCE STANDARDS AND DESIGN CRITERIA

A. Duct Reheat Coils: Ratings shall be certified in accordance with AHRI Standard 410.

B. Finned-Tube Radiation: Ratings shall be IBR Certified.

C. Convectors: Ratings shall be in accordance with Commercial Standard CS 140.

D. Units including electrical work shall be UL Listed.

PART 2 - PRODUCTS

2.1 DUCT REHEAT COILS (HOT WATER)

A. Manufacturers: Carrier, Trane, McQuay, Marlo, Temtrol, or Heatcraft

B. Reheat coils furnished with air terminal devices will be acceptable, provided coils are meeting requirements specified in this section.

C. Coils shall be constructed of 1/2" or 5/8" OD copper tubes with aluminum fins suitable for minimum working pressure to 200 psig and temperatures to 220°F.

D. Coils having steel nipples for connection are not allowed.

E. Coil fins shall be continuous serpentine or plate fin type.

F. Coil headers shall be cast iron with tubes expanded into headers or heavy seamless copper with all tubes brazed to header.

G. Casing shall have G90 galvanized steel end supports and top and bottom channels of rigid construction with allowance for expansion and contraction of finned tube section.

H. Coil frame shall be suitable for drive slip or flange and gasket connection to ductwork.

2.2 UNIT HEATERS

A. Manufacturers: Modine, McQuay, Sterling, Vulcan, Sigma, Rittling or Trane

B. Heating elements shall be constructed of copper tubing with aluminum fins and tested at 250 psig air under water.

C. Casings shall be steel phosphatized and finished in baked enamel.

D. Furnish directional louvers for horizontal units and louver cone diffuser for projection units.

E. Fans shall have aluminum blades, factory balanced and quiet in operation and furnished with safety guard.

F. Disconnect switches shall be factory-mounted at units

2.3 CABINET UNIT HEATERS

A. Manufacturers: Vulcan, McQuay, Sigma, Rittling, Sterling or Trane

B. Water coils shall be constructed of 5/8" OD seamless copper tubes with aluminum fins suitable for minimum working pressure to 250 psig and temperature to 275°F.

C. Cabinet front panels shall be 18 ga steel for horizontal units and steel for vertical units.

D. Exposed ceiling type units shall be furnished with hinged access panels to provide complete access to entire unit.

E. Units shall be furnished with filter rack and 2 sets of 1" thick glass fiber filter.

F. Cabinets shall have baked enamel finish in one of manufacturer's standard colors to be selected by Architect.

G. Fan wheels shall be centrifugal forward-curved and double-width type, statically and dynamically balanced.

H. Units shall be furnished with 3-speed switches.

I. Disconnect switches shall be factory-mounted at units.

2.4 FIN TUBE RADIATION

A. Manufacturers: Slant/Fin, Sterling, Mesteck, Vulcan or Rittling

B. Heating elements shall be constructed of aluminum fin on copper tube, supported on wall mounting brackets or floor mounted with slide cradles 3 ft on center for free expansion without noise.

C. Enclosures shall be constructed of 16 ga steel with individually removable front panels.

D. Enclosures shall be flat top design with extruded anodized aluminum grilles.

E. Enclosures shall be rust inhibited and painted with baked enamel finish in one of manufacturer's standard colors, selected by Architect.

F. Provide all necessary accessories such as inside corner, outside corners, enclosure extensions and end caps as required for complete installation as indicated on drawings and/or schedules.

G. Furnish complete with access doors at all valves.

2.5 FAN COIL UNITS

A. Manufacturers: York, Carrier, Trane, McQuay or International Environmental Corporation (IEC)

B. Unit data shall be certified in accordance with AHRI Standard 430 or 440.

C. Coils shall be constructed of 1/2" or 5/8" OD seamless copper tubes with aluminum fins suitable for minimum working pressure to 300 psig and temperatures to 200ºF. Furnish coils with manual air vents. Coil performance data shall be in accordance with AHRI Standard 410.

D. Units shall be furnished with centrifugal fans, separate hot and chilled water coils as scheduled, speed selection switches, condensate drain pans, and galvanized steel casings.

E. Units shall be furnished with double wall 18 ga steel cabinet and access to all internal mechanical and electrical devices. Cabinets of exposed units shall have baked enamel finish in one of manufacturer's standard colors, selected by Architect. Cabinets of concealed units may be prime coated or galvanized steel. Concealed units cabinet shall be double wall construction. Ducted units shall be furnished with supply and return duct collars.

F. Fan wheels shall be aluminum or galvanized steel construction, centrifugal forward-curved and double-width type, statically and dynamically balanced.

G. Unless otherwise indicated, furnish units with 3-speed permanent split capacitor motors with thermal overload protection with automatic reset.

H. Units shall be double wall construction, acoustically and thermally insulated with minimum 1" glass fiber insulation and solid wall liners. Drain pans shall be constructed of stainless steel insulated with minimum 1/2" fire retardant closed cell foam. Drain pan shall be constructed in compliance with ASHRAE 62.1-2010 and insulation shall meet requirements of NFPA 90A. Provide secondary drain pan for all ceiling mounted units with water detection switch wired to automatically shut off unit if water is detected.

I. Each unit shall include readily accessible filter rack. Furnish 2 sets of 2" thick minimum efficiency MERV-8, based on ASHRAE Test Standard 52.2, throwaway glass fiber filter for each unit.

J. Non-fused disconnect switches shall be factory mounted at units.

K. Condensate pump shall be low profile capable of 20 feet lift minimum.

2.6 ACTIVE CHILLED BEAMS

A. Manufacturers: Trox, Dadanco, Semco (Flakt-Woods), Price and TWA. Basis of design is Dadanco model ACB-40 2-way throw for 24” and Dadanco model ACB-30 1-way throw for exterior vertical application.

B. Units shall be active chilled beam design with primary air connections, induction nozzles, chilled water coils, hot water coils, integral air diffusers and removable perforated induction inlet grille for 24” wide units and independent air linear air diffuser for all others. Units are to be designed for 4-pipe heating and cooling duty as scheduled. All components of chilled beam shall meet NFPA 90A requirements for flame spread and smoke developed.

C. Units shall have removable and interchangeable plastic induction nozzles.

D. Inlet/discharge grille framework shall be constructed of aluminum or pressed steel components. Inlet grille shall be perforated steel or aluminum, of sufficient gauge to avoid sagging. Air plenum shall be constructed of minimum 22 ga steel. Interior of plenum shall be painted black if visible from room side.

E. Diffuser and induction grille face shall be powder coat or baked enamel finish of manufacturer’s standard white color for 24” wide units. Independent linear grill to be baked enamel finish of manufacturer’s standard white color. Independent grille to be coordinated with beam manufacture requirements.

F. Units shall be designed with standard US (IP) dimensions and NPT pipe connections.

G. Interior units shall be nominal 24” wide as scheduled and shall be compatible with standard t-bar ceiling grid. Exterior units shall be nominal 4” wide at ceiling as scheduled and shall be compatible with installation of independent air grille.

H. Unit face shall be drop-face or flat-face as scheduled for 24” wide units.

I. Housing shall be complete with flush mounted, removable perforated induction grille in center portion for access to cooling coil, heating coil, supply air plenum with inlet duct collars as required 5” minimum diameter, induction nozzles, and slotted supply diffusers in 1-way or 2-way configuration as scheduled.

J. Induction inlet grille on one-way or two-way throw units shall be removable for coil access. Grilles shall have safety cables or chains to support grille core during coil access

K. Provide adjustable support tabs/brackets, minimum 4 per unit for hanger support from structure.

L. Chilled water and hot water coils shall be constructed of 1/2" or 5/8" OD seamless copper tubes with minimum wall thickness of 0.016" with aluminum fins suitable for minimum working pressure to 300 psig at 75ºF temperature. Coil connections shall be NPT threaded.

M. Where scheduled, provide dual coils one for chilled water and one for hot water with factory pre-piped supply and return connections.

N. Provide flexible metal hose pipe connectors with stainless steel braided outer jacket for each chilled beam coil. Minimum live length of metal flexible hose shall be 18". Flexible connectors shall be rated for minimum working pressure of 150 psig at 70ºF and each connector shall be factory leak tested prior to shipment.

O. Submittals shall include performance data from independent testing agency. Performance data to include cooling/heating capacity at supply water temperatures scheduled, air pressure drop, supply air throw performance, sound data and water pressure drop for each chilled beam length and throw configuration.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units as indicated on drawings, and according to manufacturer's installation instructions.

B. Install branch piping to each unit with minimum of 3 elbows to allow for expansion and contraction.

C. Unless otherwise shown on drawings, mount vertical type wall mounted heating units 12" above finished floor.

D. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 DUCT REHEAT COILS

A. Comb out fins when bent or crushed before enclosing coils in ductwork. Clean dust and debris from each coil to ensure its cleanliness.

B. Seal or gasket coil connection to ductwork to meet maximum allowable leakage rate specified in Section 23 3114 - Ductwork, Part 3.

C. Unless otherwise specified, connect piping to coils with multiple rows for counter-flow arrangement.

3.3 FIN TUBE RADIATION

A. Install caulk along top of mounting strip.

B. Install enclosure brackets at not more than 4 ft intervals.

C. Install pedestal mounted units per unit manufacture requirements.

D. Unless otherwise shown on drawings, mount units with manufacturer's recommended minimum height above finished floor to provide capacities scheduled.

3.4 FAN COIL UNITS

A. Mount units above concealed ceilings or as shown on drawings with ample clearances for coil pull and filter service.

B. Mount units located on the floor as shown on drawings with ample clearance for coil pull and filter service.

C. Provide vibration isolation hangers for support of each unit.

D. Duct connections to fan coil units shall use flexible duct connections.

3.5 ACTIVE CHILLED BEAMS

A. Mount units in acoustical tile ceilings as shown on mechanical drawings and on reflected ceiling plans.

B. Support units independently of ceiling grid and directly from building structure, with minimum of 4 supports per chilled beam, using threaded rod or approved cable supported system. Wire supports are not allowed.

C. Where necessary, provide strut supports spanning under wide obstructions (ducts) to allow for proper alignment of chilled beam to ceiling grid.

D. Install manual air vents for complete venting of air from system. Provide drain valves at low points of main or branch main piping.

E. Multiple chilled beams may be zoned to match associated supply air terminals and controlled through single control valve. Refer to chilled beam schedule and/or drawings for chilled beams served by common control valve.

3.6 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

SECTION 23 82 16

COILS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 82 14 - Heating and Cooling Terminal Devices

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the documents
   3. Capacities/ratings
   4. Flow rate and pressure drop
   5. Materials of construction
   6. Dimensions and weights
   7. Manufacturer's installation instructions
   8. All other appropriate data

1.4 DESIGN CRITERIA

A. This Section covers coils in factory-packaged air handling unit, custom air handling units and field-erected air handling units.

B. Coil sizes, capacities, configuration and operating characteristics to be as shown on plans and/or as scheduled. Coil performance data shall be certified in accordance with AHRI Standard 410.

C. Unless otherwise specified, temperature profile of discharge air from entire coil face shall be uniform within 12" of coil face.

D. Provide vents at high points and drains at vertical headers, extend vents and drains to the outside of the unit casing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Trane, Marlo, Heatcraft, Aerofin, RAE, or Governair

2.2 HOT WATER COILS

A. Coils shall be constructed of 5/8" OD seamless copper tubes with aluminum fins suitable for working pressures to 200 psig and temperatures to 220°F. Coils shall be tested at 250 psig under water.

B. Coil fins shall be continuous serpentine or plate fin type with maximum of 11 fins per inch.

C. Select coils for tube velocity not less than 3.0 fps.

D. Coil headers shall be cast iron with tubes expanded into headers, steel pipe with brazed tube connections, or heavy seamless copper with tubes brazed to header.

E. Casings shall be minimum 16 ga galvanized steel having galvanized steel end supports and top and bottom channels of rigid construction with allowance for expansion and contraction of finned tube section.

2.3 CHILLED WATER COILS

A. Coils shall be constructed of 5/8" OD seamless copper tubes with 0.0095” aluminum fins suitable for working pressures to 200 psig. Coils shall be tested at 250 psig under water.

B. Coil fins shall be continuous plate fin type or flat plate to meet performance criteria.

C. Coil headers shall be constructed of cast iron with tubes expanded into headers, steel pipe with brazed tube connections, or heavy seamless copper with tubes brazed to header.

D. Casings shall be minimum stainless steel having stainless steel end supports and top and bottom channels of rigid construction with allowance for expansion and contraction of finned tube section.

E. Select coils for tube velocity not less than 3.0 fps.

F. Maximum allowable fin spacing shall be 11 fins per inch. Coil depth shall not exceed 8 rows.

PART 3 - EXECUTION

3.1 GENERAL

A. Install coils as indicated on drawings and/or as detailed. Pitch coils for proper drainage according to manufacturer's installation instructions. Install shims as required.

B. Clean oil film from coil fins with hot water/detergent as recommended by coil manufacturer.

C. Comb out fins when bent or crushed before enclosing coils in housing. Clean dust and debris from each coil to ensure its cleanliness.

D. Provide offsets in piping to facilitate coil removal. Unless otherwise specified, pipe coils for counter flow arrangement.

E. Install piping flexible connections and/or piping vibration isolation supports as specified in Section 23 0550 - Vibration Isolation.

F. Provide air vent and drain valve at each water coil.

G. Provide supply shut-off valve, return balancing valve, drain valve and air vent for each coil for air handling unit with multiple coils.

End of Section

SECTION 23 8314

RADIANT CEILING PANELS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0700 - Mechanical Systems Insulation

B. Section 23 0594 - Water Systems Test Adjust Balance

C. Section 23 2116 - Pipe and Pipe Fittings

D. Section 23 2118 - Valves

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the documents
   3. Capacities/ratings
   4. Materials of construction
   5. Dimensions
   6. Manufacturer's installation instructions
   7. All other appropriate data

B. Submit complete 1/8" or 1/4" scale plans showing layouts and complete details of all areas where radiant ceilings are shown.

C. Submit color samples of panels.

D. Submit certification by independent agency of panel performance curves and capacity ratings.

1.4 DELIVERY, STORAGE AND HANDLING

A. Deliver materials in manufacturer's original protective packaging. Store materials in area protected from weather, moisture, dirt or dust. Handle material to prevent damage, paint chipping or deformation.

1.5 SYSTEM DESCRIPTION

A. Provide complete radiant panel ceiling system where shown on drawings, as scheduled, and as herein specified.

B. Supervise installation of all equipment in ceiling panels. Provide special protection in areas where work must occur after ceiling panel installation, to avoid damage or soiling of ceiling panels.

C. Restore to original condition or replace materials damaged, or with surface defects.

1.6 RADIANT CEILING PANEL PERFORMANCE REQUIREMENTS

A. Radiant ceiling panels shall be heating only.

B. Radiant ceiling panel's performance shall be as shown on drawings and/or schedules.

C. Water pressure drop per each circuit shall not exceed 10 ft WG.

1.7 TESTING AND FILLING

A. Test each radiant panel zone including all interconnecting piping between supply and return points at 100 psig for minimum one hour before corrections are made to water circulating system. No loss of pressure shall occur during test.

B. All system piping shall be thoroughly cleaned, flushed, drained and refilled as specified in Section 23 2116 - Pipe and Pipe Fittings before radiant panels are connected into system.

C. Notify Architect and/or Engineer in writing at least 3 days before starting final testing and filling process.

D. Upon completion of testing, submit test data to Architect and/or Engineer.

1.8 QUALIFICATION AND GUARANTEE

A. Contractor shall install system in accordance with manufacturer's recommendation, complete, and to the satisfaction of Architect and/or Engineer.

B. Guarantee radiant ceiling panel system to perform as specified and to function without objectionable noise generated from thermal expansion/contraction or hydronic resonance to Architect's and/or Engineer's satisfaction and acceptance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Air-Tite, Airtex, Sterling, Aerotech or Shelly

2.2 METAL CEILING PANELS

A. Extruded Aluminum Linear Panels:
   1. System shall be equal to Air-Tite Model AR-X.
   2. Construct panels of extruded aluminum having thickness of not less than 0.06". 1/2" ID copper tubing shall be mechanically attached to aluminum faceplate. Copper tubing shall be formed into oval shape and heat conductive paste, of non-hardening kind, shall be placed between copper tubing and aluminum faceplate. Oval tube shall be held in place by aluminum saddle, which extends more than halfway around diameter of tube. Use of adhesive and/or clips to attach copper tube to extrusion will not be acceptable.
   3. Radiant Panel Size and Type:
      a. Panel size and type shall be as indicated on drawings and/or schedules.
      b. Panel size and type are indicated on the drawings and/or schedules by the following designation:

B. Panel Surface Finish:
   1. Panel surface finish shall be 2 coats of baked enamel color to be selected by Architect.

2.3 INSULATION

A. 1" thick glass fiber insulation blanket equal to Johns Manville "R" Series Microlite.

2.4 PIPING

A. Interconnecting piping between radiant panels shall be 1/2" OD type L soft drawn seamless copper tubing with wrought copper or bronze fittings. Use lead free solder equal to Bridgit or Silvabrite.

B. Tubing shall be sufficient length to allow for expansion and contraction and tubing for panels requiring access above ceiling shall be at least 6 ft in length so as to allow lowering of panel. Final 3 ft of supply and return piping connection to panels shall be made with type L soft drawn seamless copper tubing and direct connection without fitting.

PART 3 - EXECUTION

3.1 DIMENSION VERIFICATION

A. Verify all field conditions and dimensions before commencing installation.

3.2 VALVES, DRAINS, AIR VENTS, ETC.

A. For branch pipe feeding radiant panels, use top take-off for branch pipe connection to main with manual air vents.

B. Install valves, drains, air vents, etc. as shown on drawings. Install air vent at end of each radiant panel circuit.

3.3 INSULATION

A. Install insulation above radiant panels.

B. Install edges of insulation tightly butted.

C. Locate vapor barrier foil jacket top side of insulation. Jacket shall cover insulation completely so that no fiberglass insulation is exposed to ceiling plenum space.

END OF SECTION

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SECTION 23 84 13

HUMIDIFICATION EQUIPMENT

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 09 01 - Control Systems Integration

B. Section 23 09 93 - Control Sequences

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the Documents
   3. Capacities/ratings
   4. Materials of construction
   5. CV of control valves
   6. Absorption distances
   7. Dimensions
   8. Electrical data and wiring diagrams for electric type humidifiers
   9. All other appropriate data

PART 2 - PRODUCTS

2.1 ELECTRIC STEAM HUMDIFIERS

A. Manufacturers: DriSteem, Armstrong, Nortec

B. Unit shall be self contained, electric steam generating humidification system, Armstrong HC-600 or similar. Steam shall be generated by boiling off softened water.

C. Unit shall be completely pre-wired and include built-in transformer to provide 24 V supply for control circuit.

D. Provide fused disconnect switch

E. Vaporizing chamber, cover and fittings shall be constructed of Series 300 stainless steel with Heli-arc welded seams.

F. Immersion Heaters:
   1. Shall be INCOLOY allow-sheathed resistance type designed for no more than 80 W per in^2. A single element shall be provided for each electrical phase. (Three element heater bundles using pipe thread mounting are not acceptable.). Units shall utilize disposable ionic bed inserts.
   2. Unit shall thermally sense temperature within a heating element to prevent overheating.

G. Electronic Water Level Control System:
   1. Shall provide for automatic refill, low water cut off and skimmer bleed-off functions. System shall consist of:
      a. Water level sensing unit comprised of 3 probes screwed into threaded probe head.
      b. Unit shall thermally sense temperature within a heating element to prevent overheating.
      c. A solenoid operated fill valve factory mounted on front of the humidifier.
      d. Microprocessor controls.
      e. Three Levels of Heater Protection:
         1). First step shall be low water probe. In the event of failure, second step shall be raised heater element, which upon burn out shuts down entire control system.

H. Surface Water Skimmer System:
   1. Shall be furnished to provide for optimum precipitated mineral removal with minimum water waste.

I. Control Cabinet:
   1. Shall be UL-and CUL-Listed JIC enclosure. Control devices shall be mounted on sub-panel within enclosure. Control devices shall include microprocessor, magnetic contactor for each heater group, control circuit transformer, fuses for each heater, numbered terminal strip and all internal wiring. As-built wiring diagram is to be included.

J. Microprocessor Controls:
   1. Shall be factory-mounted and wired in humidifier control panel. Mounting instructions and wiring diagram shall be included. The following features and functions shall be provided:
      a. LED "heartbeat" fault indicator. Performs software self diagnosis at every start-up.
      b. Water make-up valve control and low-water safety shut down.
      c. Auto drain/flush sequence whereby microprocessor accumulates actual humidifying "on" time, and activates auto drain/flush sequence.
      d. End of session drain.
      e. Four-position functional slide switch on microprocessor board, "AUTO", "STANDBY", "DRAIN", "TEST".
      f. 100% solid state, power controller shall be mounted and wired in control cabinet.
   2. Controller shall provide the following hard-wired BAS interface points:
      a. Unit Enable/Disable (Digital Input)
      b. Fault Alarm (Contact Output)
      c. Control Signal (Analog Input, 0-5V, 0-10V or 4-20mA)

K. Furnish associated steam dispersion unit.

L. Furnish after cooler

2.2 HUMIDIFIER DISPERSION UNITS

A. Manufacturers: DriSteem, Armstrong, Carel or Pure Humidifier Co.

B. Steam dispersion unit similar to DriSteem Ultra-Sorb with complete absorption of steam within 36” of distribution grid.

C. Factory-assembled steam dispersion unit shall include the following components:
   1. Steam supply header/separator
   2. Condensate collection header
   3. Steam dispersion tubes spanning distance between 2 headers

D. Each dispersion tube shall be fitted with steam discharge tubelets inserted into tube wall. Each tubelet shall be made of thermal-resin material designed for high steam temperatures. Two rows of tubelets in each dispersion tube shall discharge steam in diametrically opposite directions, perpendicular to airflow.

E. Dispersion units to be installed in air handling unit humidification section in a 1/3, 2/3 arrangement, with the 1/3 unit being in the center.

F. Each tubelet shall extend through wall of and into center of dispersion tube and contain steam orifice sized for its required steam capacity.

G. Each packaged humidifier panel assembly of tubes and headers shall be contained within galvanized metal casing to allow convenient duct mounting, or to facilitate stacking of and/or end-to-end mounting of multiple humidifier panels in ducts or air handling unit casings.

H. Tubes and headers shall be 304 stainless steel and be Heli-arc welded.

I. Tubes and headers shall be factory insulated.

2.3 AFTERCOOLERS

A. Manufacturers: DriSteem, Penn Separator or approved equal. Units shall be similar to DriSteem Drane Kooler.

B. After coolers shall be constructed of 304 stainless steel and furnished with inlet, vent and drain connections and stainless steel striking plate.

C. Furnish unit complete with floor supports, strainer and thermostatically controlled water regulator valve to temper 212°F condensate water with 2 GPM cold water to discharge 140°C water to sanitary drain.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install make-up water and drain lines. Coordinate with Plumbing Contractor.

3.2 STEAM HUMIDIFIERS

A. Mount units in air handling units or ductwork as indicated on drawings. Provide additional support for humidifier body or distribution manifolds as recommended by manufacturer.

B. Install steam and condensate branch lines with minimum of 3 elbows to allow for expansion and contraction. Use pipe size as indicated on drawings or as recommended by manufacturer, whichever is larger. Piping shall

be copper, rubber hose is not allowed. Ream pipe and blow out at full steam pressure before connection to humidifier.

3.3 STARTUP

A. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

SECTION 23 90 00

COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description

B. Responsibilities

C. Related Work

D. Test Equipment

E. Submittals

F. Startup

G. Contractor Tests

H. Functional Performance Tests

I. Testing Documentation, Non-Conformance and Approvals

J. Operation and Maintenance Manuals

K. Training of Owner Personnel

L. Deferred Testing

M. Written Work Products

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 23 responsibilities in the commissioning process.

B. This section also includes specification of Division 20 subcontractor's responsibilities in the commissioning process.

C. The commissioned systems are listed in Section 01 91 00.

D. Commissioning requires the participation of Division 20and 23 to ensure all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 20 and 23 Contractors shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CxA, and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.3 RESPONSIBILITIES

A. Mechanical, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors of Divisions 20 and 23 are as follows (all references apply to commissioned equipment only):

1. Construction and Acceptance Phases

a. Include and itemize the cost of commissioning in the contract price.

b. In each purchase order or subcontract written, include requirements for submittal data, commissioning documentation, O&M data and training.

c. Attend a commissioning scoping meeting and other meetings necessary to facilitate the commissioning process.

d. Contractors shall provide the CxA with normal cut sheets and shop drawing submittals of commissioned equipment.

e. Provide additional requested documentation, prior to normal O&M manual submittals, to the CxA for development of start-up and functional testing procedures.

   1) Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any Owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.

   2) The Commissioning Agent may request further documentation necessary for the commissioning process.

   3) This data request may be made prior to normal submittals.

f. Provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, to the CxA for review and approval.

g. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

h. Provide limited assistance to the CxA in preparing the specific functional performance test procedures. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

i. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists from the CxA for all commissioned equipment. Submit to CxA for review and approval prior to startup. Refer to Section 01 91 00 for further details on start-up plan preparation.

j. During the startup and initial checkout process, execute the mechanical-related portions of the prefunctional checklists for all commissioned equipment.

k. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.

l. Address current punch list items before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.

m. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

n. Provide skilled technicians to perform functional performance testing under the direction of the CxA for specified equipment in Section 01 91 00. Assist the CxA in interpreting the monitoring data as necessary. Provide trending reports and graphs as may be required or available for systems being tested. Refer to Section 01 91 00 for trend requirements.

o. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, GC and Design Engineer and retest the equipment.

p. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

q. During construction, maintain as-built red-line drawings for all drawings. Update after completion of commissioning (excluding deferred testing).

r. Provide training of the Owner's operating staff using expert qualified personnel, as specified.

s. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

2. Warranty Period

a. Execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications.

b. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

B. Mechanical Contractor. The responsibilities of the HVAC Mechanical Contractor, during construction and acceptance phases in addition to those listed in (A) are:

1. Provide startup for all HVAC equipment, except for the building automation control system.

2. Assist and cooperate with the TAB contractor and CxA by:

a. Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.

b. Including cost of sheaves and belts that may be required by TAB.

c. Providing test holes in ducts and plenums where directed by TAB to allow air measurements and air balancing. Providing an approved plug.

d. Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.

3. Install a P/T plug at each water sensor that is an input point to the control system.

4. Prepare a preliminary schedule for Division 23 pipe and duct system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CxA. Update the schedule as appropriate.

5. Notify the GC or CxA depending on protocol, when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the GC or CxA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CxA has the scheduling information needed to efficiently execute the commissioning process.

C. Controls Contractor. The commissioning responsibilities of the Controls Contractor, during construction and acceptance phases in addition to those listed in (A) are:

1. Sequences of Operation Submittals. The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:

a. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.

b. All interactions and interlocks with other systems.

c. Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.

d. Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included, but will generally require additional narrative).

e. Start-up sequences.

f. Warm-up mode sequences.

g. Normal operating mode sequences.

h. Unoccupied mode sequences.

i. Shutdown sequences.

j. Capacity control sequences and equipment staging.

k. Temperature and pressure control: setbacks, setups, resets, etc.

l. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.

m. Effects of power or equipment failure with all standby component functions.

n. Sequences for all alarms and emergency shut downs.

o. Seasonal operational differences and recommendations.

p. Initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc., that will be useful during testing and operating the equipment.

q. Schedules, if known.

r. To facilitate referencing in testing procedures, all sequences shall be written in small statements, each with a number for reference. For a given system, numbers will not repeat for different sequence sections, unless the sections are numbered.

2. Control Drawings Submittal

a. The control drawings shall have a key to all abbreviations.

b. The control drawings shall contain graphic schematic depictions of the systems and each component.

c. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.

d. Provide a full points list with at least the following included for each point:

1) Controlled system

2) Point abbreviation

3) Point description

4) Display unit

5) Control point or setpoint (Yes/No)

6) Monitoring point (Yes/No)

7) Intermediate point (Yes/No)

8) Calculated point (Yes/No)

9) Key:

10) Point Description: DB temp, airflow, etc.

a) Control or Setpoint: Point that controls equipment and can have its setpoint changed (OSA, SAT, etc.)

b) Intermediate Point: Point whose value is used to make a calculation which then controls equipment (space temperatures that are averaged to a virtual point to control reset).

c) Monitoring Point: Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.

d) Calculated Point: “Virtual” point generated from calculations of other point values.

11) The Controls Contractor shall keep the CxA informed of all changes to this list during programming and setup.

3. Workstation Graphics Submittal

a. Prior to the start of testing, submit screenshots of all graphics screens for review. These must be reviewed and approved at least 6 weeks prior to testing.

4. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.
5. Assist and cooperate with the TAB contractor in the following manner:
   a. Meet with the TAB contractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB any needed unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.).
   b. For a given area, have all required prefunctional checklists, calibrations, startup and selected functional tests of the system completed and approved by the CxA prior to TAB.
   c. Provide a qualified technician to operate the controls to assist the TAB Contractor in performing TAB, or provide sufficient training for TAB to operate the system without assistance.
6. Assist and cooperate with the CxA in the following manner:
   a. Using a skilled technician who is familiar with this building, execute the functional testing of the equipment and control systems. Provide two-way radios during the testing.
   b. Execute all control system trend logs required by the CxA. Provide trend data in an organized way to permit concurrent review of multiple variables at defined time intervals. For example, a space temperature trend might show the following data every 15 minutes: VAV box airflow, discharge air temperature, reheat valve position, zone temperature and zone temperature setpoint. These five points would be tabulated in one trend report. Define units of measure for points in the trend. It is <u>not</u> acceptable to submit separate trend data for each point. Graphs of data are required for data sets containing more than 100 time intervals. Trend requirements vary with testing results and issues identified. A trend for each major system may be requested by the CxA (e.g., selected air handling, heating, cooling and other major systems).
7. The Controls Contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing, according to the process in Section 01 91 00. At a minimum, the plan shall include for each type of equipment controlled by the automatic controls:
   a. System name.
   b. List of devices.
   c. Step-by-step procedures for testing each controller after installation, including:
      1) Process of verifying proper hardware and wiring installation.
      2) Process of downloading programs to local controllers and verifying that they are addressed correctly.
      3) Process of performing operational checks of each controlled component.
      4) Plan and process for calibrating valve and damper actuators and all sensors.
      5) A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
   d. A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has “passed” and is operating within the contract parameters.
   e. A description of the instrumentation required for testing.
   f. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the CxA and TAB contractor for this determination.
8. Provide a signed and dated certification to the CxA and GC upon completion of the checkout of each controlled device, equipment and system prior to functional testing for each piece of equipment or

system, that all system programming is complete as to all respects of the Contract Documents, except functional testing requirements.

9. Beyond the control points necessary to execute all documented control sequences, provide monitoring, control and virtual points as specified.
10. List and clearly identify on the as-built duct and piping drawings, the locations of all static and differential pressure sensors (air, water and building pressure).

D. TAB Contractor. The duties of the TAB Contractor, in addition to those listed in (A) are:

1. Six weeks prior to starting TAB, submit to the GC the qualifications of the site technician for the project, including the name of the contractors and facility managers of recent projects the technician on which was lead. The Owner will approve the site technician's qualifications for this project.
2. A running log of events and issues shall be kept by the TAB field technicians. Submit handwritten reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the CxA and GC.
3. Communicate in writing to the Controls Contractor all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect the control system setup and operation.
4. Provide a draft TAB report within two weeks of completion. A copy will be provided to the CxA. The report will contain a full explanation of the methodology, assumptions and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC or NEBB.
5. Provide the CxA with any requested data, gathered, but not shown on the draft reports.
6. Conduct spot checks on all performed balancing for witness by the CxA.
7. Provide a final electronic TAB report for the CxA with details, as in the draft.

1.4 RELATED WORK

A. Refer to Section 01 91 00 for systems to be commissioned.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 01 91 00 for additional Division 20 and 23 requirements.

PART 3 - EXECUTION

3.1 SUBMITTALS

A. The Contractor shall provide submittal documentation relative to commissioning as required in this section and Section 01 91 00.

3.2 STARTUP

A. The HVAC Mechanical and Controls Contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities List in this section and in Section 01 91 00. The Contractor has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CxA. Beginning system testing before full completion, does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.3 CONTRACTOR TESTS

A. Subcontractors/installers shall forward to the Commissioning Authority, through the GC, a list and schedule of specified contractor tests. The tests shall include at least the following:

Section 23 21 16	Pipe and Pipe Fittings	3.18	Piping pressure tests
		3.19, 3.20	Pipe Flushing & Cleaning
		3.21	Initial Fill (Chemical Additives)
Section 23 31 13	Ductwork	3.8	Duct Leakage Tests
Section 23 36 14	Lab Temp and Airflow Control	3.1I	Manufacturer Start-Up report
Section 23 73 23	Factory Fabricated Custom Air Handling Units	3.15	Casing Leakage Tests
		3.1	Manufacturer Start-Up Report

B. Unless specified otherwise, provide a minimum one week prior notice to the Commissioning Authority through the GC for each specified Contractors' test.

C. Submit Contractors' test reports to the Commissioning Authority, through the GC within one week of the successful completion of each test. Contractors shall document and issue a test report for each required test. The test report shall contain all information required by the respective specification section including the test date, start time, stop time, test duration, initial values, final values, expected result, and acceptable test values (per individual specification sections). The person(s) conducting each test and the local code authority (if applicable) shall sign and date each test report indicating that the test has been successfully completed and the results are within acceptable parameters.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. Refer to Section 01 91 00 for a list of systems to be commissioned.

3.5 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

A. Refer to Section 01 91 00 for specific details on non-conformance issues relating to prefunctional checklists and tests.

B. Refer to Section 01 91 00 for issues relating to functional performance tests.

3.6 OPERATION AND MAINTENANCE (O&M) MANUALS

A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications.

B. The Contractor shall compile and prepare documentation for all equipment and systems covered in Divisions 20 and 23 and deliver this documentation to the GC for inclusion in the O&M manuals, according to this section and Section 01 91 00, prior to the training of Owner personnel.

C. The CxA shall receive a copy of the O&M manuals for review.

D. Special Control System O&M Manual Requirements. In addition to documentation that may be specified elsewhere, the Controls Contractor shall compile and organize at minimum the following data on the control system in labeled three-ring binders with indexed tabs.

1. Three copies of the controls training manuals in a separate manual from the O&M manuals.
2. Operation and Maintenance Manuals containing:
   a. Specific instructions on how to perform and apply all functions, features, modes, etc., mentioned in the controls training sections of this specification and other features of this system. These instructions shall be step-by-step. Indexes and clear tables of contents shall be included. The detailed technical manual for programming and customizing control loops and algorithms shall be included.
   b. Full as-built set of control drawings (refer to Submittal article above for details).
   c. Full as-built sequence of operations for each piece of equipment.
   d. Full points list.
   e. Full print out of all schedules and set points after testing and acceptance of the system.
   f. Full as-built print out of software program.
   g. Electronic copy on disk of the entire program for this facility.
   h. Marking of all system sensors and thermostats on the as-built floor plan and mechanical drawings with their control system designations.
   i. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
   j. Control equipment component submittals, parts lists, etc.
   k. Warranty requirements.
   l. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).
3. The manual shall be organized and subdivided with permanently labeled tabs for each of the following data in the given order:
   a. Sequences of operation
   b. Control drawings
   c. Points lists
   d. Controller/module data
   e. Thermostats and timers
   f. Sensors and DP switches
   g. Valves and valve actuators
   h. Dampers and damper actuators
   i. Program setups (software program printouts)
4. Field checkout sheets and trend logs should be provided to the CxA for inclusion in the Commissioning Record Book.

E. Review and Approvals. Review of the commissioning related sections of the O&M manuals shall be made by the Owner Advocate and by the CxA. Refer to Section 01 91 00 for details.

3.7 TRAINING OF OWNER PERSONNEL

A. The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 00 for additional details.

B. The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment or systems. Refer to Section 01 91 00 for additional details.

C. Mechanical Contractor. The Mechanical Contractor shall have the following training responsibilities:

1. Provide the CxA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00.
2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of mechanical equipment including, but not limited to, pumps, chillers, cooling, air handling units, computer room air conditioning units, boilers, fans, unit heaters, controls and water treatment systems, etc.
3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
6. The Controls Contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
7. The training sessions shall follow the outline in the table of contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
8. Training shall include:
   a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
   c. Discussion of relevant health and safety issues and concerns.
   d. Discussion of warranties and guarantees.
   e. Common troubleshooting problems and solutions.
   f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
   g. Discussion of any peculiarities of equipment installation or operation.
   h. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.
9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
10. The Mechanical Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not *controlled* by the central control system.
11. Training shall occur after functional testing is complete, unless approved otherwise by the Owner.

D. Controls Contractor. The Controls Contractor shall have the following training responsibilities:

1. Provide the CxA with a training plan four weeks before the planned training according to the outline described in Section 01 91 00.

2. The Controls Contractor shall provide designated Owner personnel training on the control system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the control system.
3. Training manuals. The standard operating manual for the system and any special training manuals will be provided for each trainee, with three extra copies left for the O&M manuals. In addition, copies of the system technical manual will be demonstrated during training and three copies submitted with the O&M manuals. Manuals shall include detailed description of the subject matter for each session. The manuals will cover all control sequences and have a definitions section that fully describes all relevant words used in the manuals *and* in all software displays. Manuals will be approved by the CxA. Copies of audiovisuals shall be delivered to the Owner.
4. The trainings will be tailored to the needs and skill-level of the trainees.
5. The trainers will be knowledgeable on the system and its use in buildings. For the on-site sessions, the most qualified trainer(s) will be used. The Owner shall approve the instructor prior to scheduling the training.
6. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

3.8 DEFERRED TESTING

A. Refer to Section 01 91 00 for requirements of deferred testing.

3.9 WRITTEN WORK PRODUCTS

A. Written work products of Contractors will consist of the start-up and initial checkout plan described in Section 01 91 00 and the filled out start-up, initial checkout and prefunctional checklists.

End of Section