ADDENDUM "C"

Date: January 30, 2023
Project: **GCPL Xenia Community Library Renovation**
76 East Market Street
Xenia, OH 45385

Documents prepared by K4 Architecture, LLC of Cincinnati, OH, Enhanse, LLC of Norwood, OH, Advantage Group Engineers of Cincinnati, OH dated 01/04/2023.

A. TO ALL BIDDERS:

This addendum is part of the contract documents. Changes shall be taken into account by the bidders in preparing their proposal. Bidders shall verify this by indicating receipt of this addendum in their bids.

B. INTENT AND SCOPE:

This addendum, issued before the receipt of proposals, is intended to provide additional information, answer questions raised by prospective bidders and to clarify or revise the requirements of the contract documents.

C. CLARIFICATIONS

1. The official issue date of this Addendum (Addendum "C") is 01/30/23, superseding the date on drawings of 01/27/23.
2. The existing roof is not a TPO roof. The existing roof is a KEE (Ketone Ethylene Ester) roof membrane, a subcategory of thermoplastic membranes.
3. Structural drawings tagged as Addendum "2" in the prior Addendum are part of Addendum "B" and should be associated as such with a "B" identification.

D. UPDATED DRAWING/SPECIFICATION LIST:

- **DRAWINGS**
  - T001
  - I101
  - I102
  - E0.1
  - E2.1
  - E2.2
  - E4.1
  - E4.3
  - M0.1
  - M0.2
  - M1.1
  - M1.2
  - M2.1
  - M2.2
  - M3.1
  - M3.2
  - M4.3
  - M4.5 (added)
  - M4.6 (added)
  - M5.1
  - M6.0
  - M6.1
  - P1.1
  - P1.2
  - P2.2

- **SPECIFICATIONS**
    - 004113 BID FORM
    - 012300 - ALTERNATES
    - 019113 – COMMISSIONING (added)
    - 092900 - GYPSUM BOARD ASSEMBLIES
    - 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
    - 220719 - PLUMBING PIPING INSULATION
    - 224213.13 - COMMERCIAL WATER CLOSETS
    - 224213.16 - COMMERCIAL URINALS
    - 224500 - EMERGENCY PLUMBING FIXTURES
    - 230500 - COMMON WORK RESULTS FOR HVAC
    - 230523.12 - BALL VALVES FOR HVAC PIPING
    - 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
    - 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
    - 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC
    - 230713 - DUCT INSULATION
    - 230716 - HVAC EQUIPMENT INSULATION
    - 230800 COMMISSIONING OF HVAC (added)
    - 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC
    - 230923.12 - CONTROL DAMPERS
    - 230923.14 - FLOW INSTRUMENTS
    - 230923.23 - PRESSURE INSTRUMENTS
    - 230993.11 - SEQUENCE OF OPERATIONS FOR HVAC DDC
    - 232123 - HYDRONIC PUMPS
    - 232500 - HVAC WATER TREATMENT
    - 232923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS
    - 233113 - METAL DUCTS
    - 233300 - AIR DUCT ACCESSORIES
    - 233416 - CENTRIFUGAL HVAC FANS
    - 233600 - AIR TERMINAL UNITS
    - 237313.16 - INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS
    - 237343.16 - OUTDOOR, SEMI-CUSTOM AIR-HANDLING UNITS
    - 237416.11 - PACKAGED ROOFTOP AIR-CONDITIONING UNITS

E. RFI's

1. **Is there additional detail for HVAC Commissioning with the project?**
    a. Please see added specification sections 019113 COMMISSIONING and 230800 COMMISSIONING OF HVAC as part of this addendum. HVAC commissioning & associated work shall be included under Alternate #6.

END OF ADDENDUM "C"

SECTION 00 01 10 - TABLE OF CONTENTS

1.1 SPECIFICATIONS DATE

A. These specifications have been produced at the date indicated in the header of each particular section. Any modifications to occur within each section will be reflected by the date to be updated and indicated in the Revision Date column included in this Table of Contents. The current issue date for all the spec sections is indicated on the cover of the Project Manual and this Table of Contents.

1.2 PROJECT LOCATION

A. Project Location:

Greene County Public Library
Xenia Community Library Renovation
76 East Market Street
Xenia, OH 45385

1.3 TABLE OF CONTENTS

DIVISION/ SECTION NUMBER & DESCRIPTION	REVISION DATE	REMARKS

PROCUREMENT AND CONTRACTING GROUP

DIVISION 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS		
INTRODUCTORY INFORMATION		

SPECIFICATIONS GROUP

GENERAL REQUIREMENTS SUBGROUP

FACILITY CONSTRUCTION SUBGROUP

DIVISION 22 – PLUMBING		

DIVISION 23 – HVAC		

END OF SECTION 00 01 10

SECTION 00 41 13 – BID FORM

A. To:

ATTENTION: Karl Colón, GCPL Director
Board of Trustees
Greene County Public Library
76 East Market Street
Xenia, OH 45385

B. For project:

Greene County Public Library
Xenia Community Library Renovation
76 East Market Street
Xenia, OH 45385

C. From:

____
(Bidding Contractor's Name)
(Submit in Duplicate)

1. We the understated, have familiarized ourselves with the local conditions affecting the cost of the work. We have visited the site and are familiar with all existing site conditions.
2. We have examined the Contract Documents identified with Project **No. 21-2113**
3. In submitting this Proposal, we agree:

   a. To hold our bid open for **sixty (60) days** following the date of bid opening.
   b. To enter into and execute a Contract, if awarded, on the basis of this Bid Form.
   c. To accomplish the work in accord with the Contract Documents.
   d. To complete the work by the time stipulated in the Proposal.

4. We understand that the Owner reserves the right to reject any or all bids and to select, substitute and negotiate to obtain mutual agreeable subcontractors and to waive all informalities.

1.2 RELATED DOCUMENTS

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

B. Related documents include: AIA Document A201 General Conditions of Contract for Construction 2007 Edition, Supplementary Conditions, the Bid Form, etc., Drawings and Specifications, and Addenda and Exhibits issued and attached to the Specifications on file in the Office of the Architect.

1.3 TC-01 – GENERAL CONTRUCTION

A. The Contractor is made aware that time is of the essence and affirms that except for delays caused by calamities, labor strikes, or acts of God, weather deviations (from 30 year norms) he will complete all work by not later than **twenty (20) months** after Owner's notice to proceed.

B. Base Bid: Refer to Section 01 10 00 for complete description of Trade Contracts

1. The Bidder proposes to perform the work defined as TC-01 – General Trades for a stipulated sum of:

____ Dollars

($________________)

C. Alternate #1: Add bollards and heavy-duty pavement to area as noted in civil drawings. Unit prices shall include all Materials, Demolition, Welding, Installation, Warranties, Local Trucking, Freight, Engineering, Overhead, Profit, Inspection, etc.

1. The Bidder proposes to perform the work defined as Alternate #1 for stipulated sum of:

____ Dollars

($________________)

D. Alternate #2a (Deduct Alternate): Remove two (2) eastern triangular "bump-outs" from the scope of work. This includes removal of roof, slab, and associated electrical items (lights, switches, etc.). Sill and glazing to remain in linear configuration only spanning between columns. Refer to Section 01 23 00 for complete description of Alternates.

1. The Bidder proposes to perform the work defined as Alternate #2a for a stipulated sum of:

____ Dollars

($________________)

E. Alternate #2b (Deduct Alternate): Remove three (3) southern triangular "bump-outs" from the scope of work. This includes removal of roof, slab, and associated electrical items (lights, switches, etc.). Glazing to remain in linear configuration only, spanning between columns. Refer to Section 01 23 00 for complete description of Alternates.

1. The Bidder proposes to perform the work defined as Alternate #2b for stipulated sum of:

____ Dollars

($_________________)

F. Alternate #3: Demolish CMU and existing curtain wall system at youth services. Replacing with new steel and curtain wall system. Refer to Section 01 22 00 for complete description of Unit Prices and 01 23 00 for complete description of Alternates. Unit prices shall include all Materials, Demolition, Welding, Installation, Warranties, Local Trucking, Freight, Engineering, Overhead, Profit, Inspection, etc.
   1. The Bidder proposes to perform the work defined as Alternate #3 for stipulated sum of:

____ Dollars

($_________________)

G. Alternate #4: Demo and replace existing second-floor single windows (count: 21 windows) on the south and east façade (southeast corner) to match new second floor window configuration. Refer to Section 01 22 00 for complete description of Unit Prices and 01 23 00 for complete description of Alternates. Unit prices shall include all Materials, Demolition, Welding, Installation, Warranties, Local Trucking, Freight, Engineering, Overhead, Profit, Inspection, etc.
   1. The Bidder proposes to perform the work defined as Alternate #4 for stipulated sum of:

____ Dollars

($_________________)

H. Alternate #5: Add security film to first floor windows along Youth and Adult stacks. Refer to Section 01 22 00 for complete description of Unit Prices and 01 23 00 for complete description of Alternates. Unit prices shall include all Materials, Demolition, Welding, Installation, Warranties, Local Trucking, Freight, Engineering, Overhead, Profit, Inspection, etc.
   1. The Bidder proposes to perform the work defined as Alternate #5 for stipulated sum of:

____ Dollars

($_________________)

I. Alternate #6: Commissioning of HVAC. Refer to Sections 01 91 13 and 23 08 00 for complete description of commissioning work.
   1. The Bidder proposes to perform the work defined as Alternate #6 for stipulated sum of:

____ Dollars

($_________________)

J. Bid Itemization: Break down construction costs based on the following categories as described in more detail in Section 01 10 00 Summary

1. Site Work ($__________________________)
2. Envelope ($__________________________)
3. First Floor ($__________________________)
4. Second Floor ($__________________________)
5. Elevator ($__________________________)
6. Mechanical ($__________________________)
7. Plumbing ($__________________________)
8. Electrical ($__________________________)
9. Suppression ($__________________________)
10. Replace one upper level window ($__________________________)

ATTACHMENTS:

K. Accompanying this Proposal are the following:

1. Section 00 43 13 – Bid Guaranty and Contract Bond.
2. AIA A305 – Contractors Qualification Statement
3. Section 00 45 13 – Personal Property Tax Statement
4. Section 00 45 19 – Non-Collusion Affidavit.
5. Certificate of Insurance
6. Bureau of Workers' Compensation Certificate

1.4 ADDENDUM RECEIPT:

A. The receipt of the following addenda to the Bidding Documents is hereby acknowledged:

No.___________ Dated _______________ No.___________ Dated ________________

No.___________ Dated _______________ No.___________ Dated ________________

1.5 EXTRA WORK AND CHANGES IN THE WORK

A. Extra work and changes in the work not called for in the Contract Documents will be reviewed by Architect and performed only on written authorization from the Owner. The Contractor will be paid for the extra work and changes so authorized on the basis of whichever of the following methods is agreed upon for the specific item by the Owner and Contractor:

1. As provided in AIA A201 paragraph 7.3.3.

1.6 TEMPORARY FACILITIES

A. Cost or use charges and applicable fees for temporary facilities shall be included in the Contract Sum. Allow other entities to use temporary services and facilities without cost, including, but not limited to, Owner, Architect, testing agencies, and authorities having jurisdiction.

1.7 QUALIFICATIONS:

A. The Owner reserves the right to reject any or all bids and to select, substitute and negotiate to obtain mutual agreeable subcontractors and to waive all informalities.

1.8 BIDDER SIGNATURES:

A. In testimony whereof, the Bidder has caused this proposal to be signed by its president and secretary and fixed its corporate seal this day of: ___________________________, 20___.

____
Name of Bidder

____
State of the Company

Title:____
Person Legally Authorized to Bind Bidder to Contract

By: ____ Company Seal Signature

1.9 PARTNERSHIP SIGNATURES:

A. In testimony whereof, the Bidder (a Partnership) has caused this proposal to be signed by each partner this day of _______________________, 20___.

____
Partner

____
Partner

____
Partner

END OF SECTION 00 41 13

SECTION 01 23 00 – ALTERNATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes administrative and procedural requirements for alternates.

1.3 DEFINITIONS

A. Alternate: An amount proposed by bidders and stated on the Bid Form for certain work defined in the Bidding Requirements that may be added to or deducted from the base bid amount if Owner decides to accept a corresponding change either in the amount of construction to be completed or in the products, materials, equipment, systems, or installation methods described in the Contract Documents.

1. Alternates described in this Section are part of the Work only if enumerated in the Agreement.
2. The cost or credit for each alternate is the net addition to or deduction from the Contract Sum to incorporate alternate into the Work. No other adjustments are made to the Contract Sum.

1.4 PROCEDURES

A. Coordination: Modify or adjust affected adjacent work as necessary to completely integrate work of the alternate into Project.

1. Include as part of each alternate, miscellaneous devices, accessory objects, and similar items incidental to or required for a complete installation whether or not indicated as part of alternate.

B. Notification: Immediately following award of the Contract, notify each party involved, in writing, of the status of each alternate. Indicate if alternates have been accepted, rejected, or deferred for later consideration. Include a complete description of negotiated modifications to alternates.

C. Execute accepted alternates under the same conditions as other work of the Contract.

D. Schedule: A schedule of alternates is included at the end of this Section. Specification Sections referenced in schedule contain requirements for materials necessary to achieve the work described under each alternate.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 SCHEDULE OF ALTERNATES

A. Alternate #1: Add bollards and heavy-duty pavement to area as noted in civil drawings.

B. Alternate #2a (Deduct Alternate): Remove two (2) eastern triangular “bump-outs” from the scope of work. This includes removal of roof, slab, and associated electrical items (lights, switches, etc.). Sill and glazing to remain in linear configuration only spanning between columns.

C. Alternate #2b (Deduct Alternate): Remove three (3) southern triangular “bump-outs” from the scope of work. This includes removal of roof, slab, and associated electrical items (lights, switches, etc.). Glazing to remain in linear configuration only, spanning between columns.

D. Alternate #3: Demolish CMU and existing curtain wall system at youth services. Replacing with new steel and curtain wall system.

E. Alternate #4: Demo and replace existing second-floor single windows (count: 21 windows) on the south and east façade (southeast corner) to match new second floor window configuration.

F. Alternate #5: Add 3M security film to first floor windows along Youth and Adult stacks.

G. Alternate #6: Commissioning of HVAC.

END OF SECTION 01 23 00

SECTION 01 91 13 – GENERAL COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes administrative and procedural requirements that apply to implementation of commissioning.

B. General Provisions for Commissioning:

1. Selected building systems and equipment to be commissioned are identified in Division 23.
2. The commissioning process shall be directed by the Commissioning Authority.
3. The Commissioning Authority is to be independent, acting as a third-party service, to be contracted directly to the General Contractor.
4. The responsible professional shall act as the Commissioning Authority, and shall be responsible for executing the commissioning process as defined in Division 23 as directed by the Commissioning Authority, and as defined in Division 23.
5. The commissioning process is defined in Division 23 and includes responsibilities for each Commissioning Team member including the Commissioning Agent.

C. Related Sections and References include the following:

1. Division 01 23 00 – Alternates

2. Division 23 08 00 – Commissioning of HVAC

3. ASHRAE Guideline 0-2019 - The Commissioning Process

1.3 DEFINITIONS

A. Commissioning (Cx): A quality assurance process that documents specified systems and components that are provided and tested to meet the Owner’s needs and the design intent in accordance with the Contract Documents.

B. Commissioning Authority (CxA): The professional, appointed by the General Contractor, to direct and coordinate the commissioning process. The General Contractor shall assign a representative with expertise and authority to act on its behalf to participate in the commissioning process. Note that the Commissioning Authority and the General Contractor are not allowed to be the same organization or person.

C. Commissioning Plan: An overall plan that provides the structure, schedule, and coordination planning for the commissioning process.

D. Commissioning Team: Shall consist of, but not be limited to, the Owner, Design Professional, General Contractor, Division 23 subcontractor, Commissioning Agent, and other specialists as associated with the commissioning.

E. Design Intent (DI): A document prepared by the Design Professionals that summarizes design goals of the design phase.

F. See Division 23 08 00, Section 1.2 for additional definitions related to Commissioning.

1.4 SUBMITTALS

A. See Section 23 08 00 for a list of submittals.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 See Section 23 08 00, Part 3 for Execution requirements and processes.

END OF SECTION 01 91 13

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. This Section includes the following:

1. Interior gypsum board.
2. Tile backing panels.
3. Abuse resistant gypsum board.
4. Impact resistant gypsum board.

B. Related Sections include the following:

1. Division 05 Section "Cold-Formed Metal Framing" for load-bearing steel framing that supports gypsum board.
2. Division 06 Section "Sheathing" for gypsum sheathing.
3. Division 07 Section "Thermal Insulation" for insulation and vapor retarders installed in assemblies that incorporate gypsum board.
4. Division 09 Section "Non-Structural Metal Framing" for non-structural framing and suspension systems that support gypsum board.
5. Division 09 painting Sections for primers applied to gypsum board surfaces.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

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

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.

1.5 STORAGE AND HANDLING

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

1.6 PROJECT CONDITIONS

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

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

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

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

PART 2 - PRODUCTS

2.1 PANELS, GENERAL

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

2.2 INTERIOR GYPSUM BOARD

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

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

   a. American Gypsum Co.
   b. G-P Gypsum.
   c. National Gypsum Company.
   d. USG Corporation.

B. Regular Type:

1. Thickness: As indicated on Drawings, 5/8” minimum
2. Long Edges: Tapered.

C. Type X:

1. Thickness: As indicated on Drawings, 5/8” minimum

2. Long Edges: Tapered.

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

1. Core: 5/8 inch, Type X.
2. Long Edges: Tapered.

E. Abuse-Resistant Type: Manufactured to produce greater resistance to surface indentation, through-penetration (impact resistance), and abrasion than standard, regular-type and Type X gypsum board.

1. Location: Refer to Drawings.
2. Performance Criteria - Wall Assembly STC: min [44].
3. Panel Physical Characteristics

a. Core: Fire-resistance rated gypsum core, with additives to enhance surface indentation resistance and impact resistance
b. Surface paper: Abrasion resistant, 100 percent recycled content moisture/mold/mildew resistant paper on front, back and long edges
c. Long Edges: Tapered.
d. Overall thickness: 5/8 inch
e. Panel complies with Type X requirements of ASTM C 1396
f. Surface Abrasion Resistance: Classification Level 3 in accordance with ASTM C 1629
g. Indentation Resistance: Classification Level 1 in accordance with ASTM C 1629.
h. Soft Body Impact Resistance: Classification Level 2 in accordance with ASTM C 1629
i. Hard Body Impact Resistance: Classification Level 1 in accordance with ASTM C 1629.

F. High-Impact Type: Manufactured with Type X core, plastic film laminated to back side for greater resistance to through-penetration (impact resistance).

1. Location: Refer to Drawings.
2. Performance Criteria - Wall Assembly STC: min [44]
3. Panel Physical Characteristics

a. Core: Fire-resistance rated gypsum core, with additives to enhance mold/mildew resistance, surface indentation resistance, impact resistance and moisture and mold resistant
b. Surface paper: Abrasion resistant, 100 percent recycled content moisture/mold/mildew resistant paper on front, back and long edges
c. Embedded fiberglass mesh
d. Long Edges: Tapered
e. Overall thickness: 5/8 inch
f. Panel complies with Type X requirements of ASTM C 1396
g. Surface Abrasion Resistance: Classification Level 3 in accordance with ASTM C 1629

h. Indentation Resistance: Classification Level 1 in accordance with ASTM C 1629.
i. Soft Body Impact Resistance: Classification Level 3 in accordance with ASTM C 1629
j. Hard Body Impact Resistance: Classification Level 3 in accordance with ASTM C 1629.

2.3 TILE BACKING PANELS

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

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

a. American Gypsum Co.
b. G-P Gypsum.
c. National Gypsum Company.
d. USG Corporation.

2. Core: As indicated on Drawings, 5/8 inch minimum, Type X.

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

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

a. Product: Subject to compliance with requirements, provide "DensShield Tile Guard" by G-P Gypsum.

2. Complying with ASTM C1177/C 1177M.

a. Product: Subject to compliance with requirements, provide "DensArmor Plus Interior Guard" by G-P Gypsum.

3. Core: As indicated on Drawings, 5/8 inch minimum, Type X.

2.4 TRIM ACCESSORIES

A. Interior Trim: ASTM C 1047.

1. Material: Galvanized or aluminum-coated steel sheet, 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.

g. Curved-Edge Cornerbead: With notched or flexible flanges.

B. Aluminum Trim: Extruded accessories of profiles and dimensions indicated.

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

a. Fry Reglet Corp.
b. Gordon, Inc.
c. Pittcon Industries.

2. Aluminum: Alloy and temper with not less than the strength and durability properties of ASTM B 221 (ASTM B 221M), Alloy 6063-T5.
3. Finish: Corrosion-resistant primer compatible with joint compound and finish materials specified.

2.5 JOINT TREATMENT MATERIALS

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

B. Joint Tape:

1. Interior Gypsum Wallboard: Paper.
2. Exterior Gypsum Soffit Board: Paper.
3. Glass-Mat Gypsum Sheathing Board: 10-by-10 glass mesh.
4. Tile Backing Panels: As recommended by panel manufacturer.

C. Joint Compound for Interior Gypsum Wallboard: For each coat use formulation that is compatible with other compounds applied on previous or for successive coats.

1. Prefilling: At open joints, 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 drying-type, all-purpose compound.

a. Use setting-type compound for installing paper-faced metal trim accessories.

3. Fill Coat: For second coat, use drying-type, all-purpose compound.
4. Finish Coat: For third coat, use drying-type, all-purpose compound.
5. Skim Coat: For final coat of Level 5 finish, use [setting-type, sandable topping compound or drying-type, all-purpose compound

D. Joint Compound for Tile Backing Panels:

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

2.6 AUXILIARY MATERIALS

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

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

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

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

1. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch (0.84 to 2.84 mm) thick.

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.

2.7 ACOUSTICAL SEALANT

A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

1. Acoustical Sealant for Exposed and Concealed Joints:

a. Pecora Corp.; AC-20 FTR Acoustical and Insulation Sealant.
b. United States Gypsum Co.; SHEETROCK Acoustical Sealant.

B. Acoustical Sealant for Exposed and Concealed Joints: 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 that effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

3.2 APPLYING AND FINISHING PANELS, GENERAL

A. Comply with ASTM C 840.

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

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

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

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

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

1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. (0.7 sq. m) in area.
2. Fit gypsum panels around ducts, pipes, and conduits.
3. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4- to 3/8-inch- (6.4- to 9.5-mm-) wide joints to install sealant.

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

H. 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. Regular Type: As indicated on Drawings.
2. Type X: As indicated on Drawings.
3. Ceiling Type: As indicated on Drawings.
4. Moisture- and Mold-Resistant Type: In bathrooms, toilet rooms, shower rooms, janitors closets and as indicated on Drawings.

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 horizontally (perpendicular to framing), unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.

   a. Stagger abutting end joints not less than one framing member in alternate courses of 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 1 framing member, 16 inches (400 mm) 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 and face layers separately to supports with screws.

3.4 APPLYING TILE BACKING PANELS

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

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

C. Cementitious Backer Units: ANSI A108.11, at showers, tubs, and where indicated.

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.
2. Bullnose Bead: Use where indicated.
3. LC-Bead: Use at exposed panel edges and where indicated.
4. L-Bead: Use where indicated.
5. U-Bead: Use at exposed panel edges and where indicated.
6. Curved-Edge Cornerbead: Use at curved openings.

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 those with trim having flanges not intended for tape.

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

1. Level 1: Ceiling plenum areas, concealed areas, and where indicated on drawings.
2. Level 2: Panels that are substrate for tile and where indicated on Drawings.

3. Level 4: All exposed locations

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

E. Glass-Mat Gypsum Sheathing Board: Finish according to manufacturer's written instructions for use as exposed soffit board.

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

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

3.7 PROTECTION

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

B. Remove and replace panels that are wet, moisture damaged, and mold damaged.

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

END OF SECTION 09 29 00

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fastener systems.
4. Pipe-positioning systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
2. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.
3. Environmental Product Declaration (EPD): For each product.
4. Product Certificates: For indigenous materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each indigenous material.
5. Environmental Product Declaration: For each product.
6. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each regional material.
7. Environmental Product Declaration: For each product.
8. Environmental Product Declaration: For each product.
9. Third-Party Certifications: For each product.
10. Third-Party Certified Life Cycle Assessment: For each product.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Fiberglass strut systems.
4. Pipe stands.
5. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Division 1 specification sections for Quality Requirements, to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pre-galvanized, hot-dip galvanized, or electro-galvanized.
3. Adjustable band type hangers, type 10, MSS-SP-69.

4. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
5. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping. Clevis type 1 hangers, MSS-SP-58.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of hot dipped galvanized steel.

B. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper coated steel or stainless steel

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly, made from structural-carbon-steel shapes, with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 FASTENER SYSTEMS

A. Reversible beam clamps, malleable iron with electro-galvanized finish, locknut and retaining strap for retrofit applications, MSS-SP-69, UL listed.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: Zinc-coated or stainless steel.
2. Outdoor Applications: Stainless steel.

2.5 PIPE-POSITIONING SYSTEMS

A. Description: IAPMO PS 42 positioning system composed of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.6 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Division 7 specifications for Penetration Firestopping for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 INSTALLATION OF HANGER AND SUPPORT

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Provide adjustable band hangers for piping exposed to public view, nut and threaded rod on top, paint ready finish.

C. For insulated piping provide padded clevis type hangers for piping exposed to public view, nut and threaded rod on top, paint ready finish.

D. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

E. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.

F. Fastener System Installation:

1. Powder-actuated fasteners will not be allowed.
2. Install mechanical-expansion anchors in concrete, after concrete is placed and

completely cured. Install fasteners according to manufacturer's written instructions.

G. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

K. Install lateral bracing with pipe hangers and supports to prevent swaying.

L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers,

M. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

O. Insulated Piping:

1. Attach clamps and spacers to piping.
    a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. MSS SP-58, Type 39: Install protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
    a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. MSS SP-58, Type 40: Install protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
    a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:

a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
b. NPS 4: 12 inches long and 0.06 inch thick.

5. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 INSTALLATION OF EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup:

1. Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

a. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

2. Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Division 9 specification sections.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers, metal framing systems, and attachments for general service applications.

F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal hanger-shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 4.
2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 4 if little or no insulation is required.
4. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
5. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated, stationary pipes NPS 3/4 to NPS 8.
6. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
7. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8..

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment of up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11 split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. C-Clamps (MSS Type 23): For structural shapes.
6. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
7. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
8. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
9. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.

10. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
11. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
12. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.

O. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

Q. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Domestic recirculating hot-water piping.
4. Sanitary waste piping exposed to freezing conditions.
5. Supplies and drains for handicap-accessible lavatories and sinks.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
2. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
3. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include name of the manufacturer, fabricator, type, description, and size, as well as ASTM standard designation and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less
2. All Insulation Installed Indoors; Outdoors-Installed Insulation in Contact with Airstream: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
3. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less

2.2 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials are applied.

B. Products do not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come into contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric: Closed-cell or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg F and 220 deg F. Comply with ASTM C534/C534M, Type I for tubular materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Aeroflex USA
   b. Armacell LLC
   c. K-Flex USA

G. Glass-Fiber, Preformed Pipe: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 850 deg F in accordance with ASTM C411. Comply with ASTM C547.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Johns Manville; a Berkshire Hathaway company
b. Knauf Insulation
c. Manson Insulation Inc
d. Owens Corning

2. Preformed Pipe Insulation: Type I, Grade A with factory-applied ASJ jacket.
3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.3 INSULATING CEMENTS

A. Glass-Fiber and Mineral Wool Insulating Cement: Comply with ASTM C195.

B. Glass-Fiber and Mineral Wool Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

2.4 ADHESIVES

A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

1. Adhesive: As recommended by cellular glass manufacturer and with a VOC content of 80 g/L or less.
2. Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.

C. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.

1. Adhesive: As recommended by flexible elastomeric and polyolefin manufacturer and with a VOC content of 80 g/L or less.
2. Flame-spread index is 25 or less and smoke-developed index is 50 or less as tested in accordance with ASTM E84.
3. Wet Flash Point: Below 0 deg F.
4. Service Temperature Range: 40 to 200 deg F.
5. Color: Black.

D. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Adhesive: As recommended by mineral fiber manufacturer and with a VOC content of 80 g/L or less.

E. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.

1. Adhesives shall have a VOC content of 80 g/L or less.

F. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Adhesive: As recommended by Adhesive - PVC Jacket manufacturer and with a VOC content of 50 g/L or less.

2.5 MASTICS AND COATINGS

A. Materials are compatible with insulation materials, jackets, and substrates.

1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.

1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Comply with MIL-PRF-19565C, Type II, for permeance requirements[, with supplier listing on DOD QPD - Qualified Products Database].
4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.6 LAGGING ADHESIVES

A. Lagging Adhesives: Adhesives comply with MIL-A-3316C, Class I, Grade A, and are compatible with insulation materials, jackets, and substrates.

1. Adhesive shall be as recommended by insulation manufacturer and shall have a VOC content of 50 g/L or less.
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
3. Service Temperature Range:20 to plus 180 deg F
4. Color: White.

2.7 SEALANTS

A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.

1. Permanently flexible, elastomeric sealant.
2. Service Temperature Range: Minus 58 to plus 176 deg F.

3. Color: White or gray.
4. Sealant shall have a VOC content of 420 g/L or less.

B. FSK and Metal Jacket Flashing Sealants:

1. Fire- and water-resistant, flexible, elastomeric sealant.
2. Service Temperature Range: Minus 40 to plus 250 deg F.
3. Color: Aluminum.
4. Sealant shall have a VOC content of 420 g/L or less.

C. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

1. Fire- and water-resistant, flexible, elastomeric sealant.
2. Service Temperature Range: Minus 40 to plus 250 deg F.
3. Color: White.
4. Sealant shall have a VOC content of 420 g/L or less.

2.8 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
4. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136 Types I, II, III, IV, and VII.

2.9 FIELD-APPLIED JACKETS

A. Field-applied jackets comply with ASTM C1136, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled, roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Adhesive: As recommended by jacket material manufacturer.
2. Color: White.
3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.10 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

1. Width: 3 inches.
2. Thickness: 6.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Width: 2 inches.
2. Thickness: 6 mils.
3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

2.11 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A240/A240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

2.12 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

1. Description: Manufactured plastic wraps with internal side insulation for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements. White finish.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range of between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 EXISTING PIPING REQUIREMENTS

A. Provide new insulation, in accordance with part 2 and part 3 of these specifications, on existing domestic cold water, domestic hot water, domestic hot water return and drainage piping where existing piping insulation is damaged; completely seal where new insulation meets existing un-damaged insulation.

B. Provide additional jacket, factory and/or field applied, in accordance with part 2 and part 3 of these specifications, on existing domestic cold water, domestic hot water, domestic hot water return and drainage piping, where existing piping insulation is damaged: completely seal new jacket to existing un-damaged jacketing at points where these meet.

3.4 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

D. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) of horizontal runs.

E. Where insulated piping will be exposed to view in public spaces, arrange and install such that horizontal joints and seams close at top side of piping, furthest from public view.

F. Install multiple layers of insulation with longitudinal and end seams staggered.

G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

H. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents, unless otherwise approved by the Construction Manager.

I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

J. Install insulation with least number of joints practical.

K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation

material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

M. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 4 inches o.c. For below-ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

N. Cut insulation in a manner to avoid compressing insulation.

O. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

P. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

Q. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.5 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor

insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Division 7 specification sections for penetration firestopping, for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 7 specification sections for Penetration Firestopping.

3.6 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles below.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation of same material and thickness as that used for adjacent pipe. Each piece is butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour

that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate flanges, mechanical couplings, and unions, using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
6. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
7. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install sections of pipe insulation and miter if required in accordance with manufacturer's written instructions.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated valve covers manufactured of same material as that of pipe insulation when available.
2. When prefabricated valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 INSTALLATION OF GLASS-FIBER AND MINERAL WOOL INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with glass-fiber or mineral-wool blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of

pipe insulation when available.
2. When prefabricated insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated sections are not available, install fabricated sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.9 INSTALLATION OF FIELD-APPLIED JACKETS

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.10 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 9 specification sections for

Interior Painting and Exterior Painting.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
    a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless steel jackets.

3.11 FIELD QUALITY CONTROL

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

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation.

D. All insulation applications will be considered defective if they do not pass tests and inspections.

E. Prepare and submit, to the construction manager, test and inspection reports, for review and approval.

3.12 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.13 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. NPS 1 and Smaller: Insulation is one of the following:
    a. Flexible Elastomeric: 1/2 inch thick.
    b. Glass-Fiber, Preformed Pipe Insulation, Type I: 3/4 inch thick.
2. NPS 1-1/4 and Larger: Insulation is the following:

a. glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

3. A continuous vapor barrier shall be provided for all domestic cold water insulation applications.

B. Domestic Hot and Recirculated Hot Water:

1. NPS 1 and Smaller: Insulation is one of the following:

a. Flexible Elastomeric: 3/4 inch thick.
b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1” thick.

2. NPS 1-1/4 and Larger: Insulation is the following:

a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

C. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:

1. All Pipe Sizes: Insulation is one of the following:

a. Flexible Elastomeric: 1/2 inch thick.
b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

3.14 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

D. Piping, Exposed in mechanical spaces or exposed to view in occupied spaces:

1. PVC: 20 mils minimum; 30 mils thick for nominal piping size of 2” diameter or larger.

END OF SECTION 220719

SECTION 224213.13 - COMMERCIAL WATER CLOSETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wall-mounted water closets.
2. Flushometer valves.
3. Toilet seats.
4. Supports.

1.2 DEFINITIONS

A. Standard-Efficiency Flush Volume: 1.6 gal. per flush.

B. High-Efficiency Flush Volume: 1.28 gal. or less per flush.

C. WaterSense Fixture: Water closet and/or flushometer valve/tank certified by the EPA to meet the WaterSense performance criteria.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water closets.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for fixtures, connection points, connected devices, flush valves.

C. Sustainable Design Submittals:

1. Product Data: For water consumption.
2. Plumbing Fixtures: Provide the following:
   a. Manufacturer cut sheet indicating water consumption.
   b. WaterSense certification for residential fixtures, commercial water closets, commercial urinals, and commercial showers.
3. Plumbing Fixtures: Provide manufacturer's cut sheets for plumbing fixtures indicating flush or flow rates.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves and sensors to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Materials: Furnish extra materials to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Flushometer-Valve Repair Kits: Equal to one for each fixture, of each type.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Standards:

1. Comply with ASME A112.19.2/CSA B45.1 for water closets.
2. Comply with ASME A112.19.5/CSA B45.15 for flush valves and spuds for water closets and tanks.
3. Comply with ASSE 1037/ASME A112.1037/CSA B125.37 for flush valves.
4. Comply with IAMPO/ANSI Z124.5 for water-closet (toilet) seats.
5. Comply with ASME A112.6.1M for water-closet supports.
6. Comply with ICC A117.1 for ADA-compliant water closets.
7. Comply with ASTM A1045 for flexible PVC gaskets used in connection of vitreous china water closets to sanitary drainage systems.
8. Comply with ASME A112.4.3 for plastic fittings used in connection of vitreous china water closets to sanitary drainage systems.

2.2 WALL-MOUNTED WATER CLOSETS

A. Water Closets - Wall Mounted, top spud, siphon jet action, elongated front rim bowl:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Zurn Industries
b. American Standard
c. Kohler Co
d. TOTO USA, INC

2. Source Limitations: Obtain water closets from single source from single manufacturer.
3. Bowl:

a. Material: Vitreous china.
b. Type: Siphon jet.
c. Style: Flushometer valve.
d. Mounting Height: ADA compliant.
e. Rim Contour: Elongated.
f. Spud Size and Location: NPS 1-1/2; back.
g. Glazed trapway: minimum 2-1/8 inch
h. Color: White.
i. ASME A119.2 compliant

2.3 FLUSHOMETER VALVES

A. Flushometer Valves – Diaphragm valve, Sensor Operated, Battery Powered.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:

   a. Sloan Valve Company
   b. American Standard
   c. Kohler Co
   d. TOTO USA, INC
   e. Zurn Industries, LLC

2. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
3. Minimum Pressure Rating: 125 psig.
4. Operating pressures: Range 15 – 80 psig
5. Features: Include integral check stop and backflow-prevention device.
6. Material: Brass body with corrosion-resistant components.
7. Style: Exposed.
8. Integral stop seat and vacuum breaker.
9. Exposed Flushometer-Valve Finish: Chrome-plated.
10. Panel Finish: Chrome-plated or stainless steel.
11. Trip Mechanism: Battery-powered electronic sensor; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
12. Rated 6 yr battery life.
13. Consumption: 1.28 gal. per flush.
14. Minimum Inlet: NPS 1.
15. Minimum Outlet: NPS 1-1/2.
16. ASSE 1037 compliant
17. ANSI 112.19.2 compliant

2.4 TOILET SEATS

A. Toilet Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Zurn Industries
   b. American Standard
   c. Bemis Manufacturing Company
   d. Kohler Co
   e. TOTO USA, INC

2. Source Limitations: Obtain toilet seat from single source from single manufacturer.
3. Material: Plastic.
4. Type: Commercial Heavy duty.
5. Shape: Elongated rim, open front.

6. Hinge Material: Noncorroding metal.
7. Color: White
8. Surface Treatment: Antimicrobial.

2.5 SUPPORTS

A. Water-Closet Carrier:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Zurn Industries
   b. Jay R. Smith Mfg
   c. Josam Company
   d. Watts
2. Source Limitations: Obtain water-closet carrier from single source from single manufacturer.
3. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space where required.
4. Compliance with ASTM A112.6.1 standard.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water-supply piping and sanitary drainage and vent piping systems to verify actual locations of piping connections before water-closet installation.

B. Examine walls and floors for suitable conditions where water closets will be installed.

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

3.2 INSTALLATION, GENERAL

A. Water-Closet Installation:

1. Install level and plumb.
2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
3. Install accessible, wall-mounted water closets at mounting height in accordance with ICC A117.1.

B. Support Installation:

1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
2. Use carrier supports with waste-fitting assembly and seal.
3. Install floor-mounted, back-outlet water closets attached to building floor

substrate, onto waste-fitting seals; and attach to support.
4. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.
5. Measure support height installation from finished floor, not structural floor.

C. Flushometer-Valve Installation:

1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
4. Install actuators in locations easily reachable for people with disabilities.
5. Install new batteries in battery-powered, electronic-sensor mechanisms.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."

F. Joint Sealing:

1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.
3. Comply with sealant requirements specified in Division 7 specification sections for Joint Sealants.

3.3 PIPING CONNECTIONS

A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Install new batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed water closets and fittings.

C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.13

SECTION 224213.16 - COMMERCIAL URINALS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wall-hung urinals.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for urinals.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

1. Product Data: For water consumption.
2. Plumbing Fixtures: Provide the following:

a. Manufacturer cut sheet indicating water consumption.
b. WaterSense certification for residential fixtures, commercial water closets, commercial urinals, and commercial showers.

3. Plumbing Fixtures: Provide manufacturer's cut sheets for plumbing fixtures indicating flush or flow rates.

C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

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

1. Flushometer-Valve Repair Kits: Furnish one for each fixture installed.

PART 2 - PRODUCTS

2.1 WALL-HUNG URINALS

A. Urinals - Wall Hung, Back Outlet, Washdown: Accessible.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:

    a. Zurn
    b. American Standard
    c. Kohler Co
    d. TOTO USA

2. Fixture:

    a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5/CSA B45.15, ANSI A117.1.
    b. Material: Vitreous china.
    c. Type: Washdown with extended shields.
    d. Strainer or Trapway: Manufacturer's standard strainer with integral trap.
    e. Water Consumption: 0.125 gpf.
    f. Spud Size and Location: NPS 3/4, top.
    g. Outlet Size and Location: NPS 2, back.
    h. Color: White.

B. FLUSHOMETER VALVES

1. Flushometer Valves – Diaphragm valve, Sensor Operated, Battery Powered.

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:

        1) Sloan Valve Company
        2) American Standard
        3) Kohler Co
        4) TOTO USA, INC
        5) Zurn Industries, LLC

    b. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
    c. Minimum Pressure Rating: 125 psig.
    d. Operating pressures: Range 15 – 80 psig
    e. Features: Include integral check stop and backflow-prevention device.
    f. Material: Brass body with corrosion-resistant components.
    g. Style: Exposed.
    h. Integral stop seat and vacuum breaker.
    i. Exposed Flushometer-Valve Finish: Chrome-plated.
    j. Panel Finish: Chrome-plated or stainless steel.

k. Trip Mechanism: Battery-powered electronic sensor; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
l. Rated 6 yr battery life.
m. Consumption: 1.28 gal. per flush.
n. Minimum Inlet: NPS 3/4.
o. Minimum Outlet: NPS 3/4.
p. ASSE 1037 compliant
q. ANSI 112.19.2 compliant

C. Waste Fitting:

a. Standard: ASME A112.19.2/CSA B125.2 for coupling.
b. Size: NPS 2.

D. Support: Carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights.

1. Urinal Mounting Height: Handicapped/elderly according to ICC A117.1.
2. Compliant with ASTM A112.6.1 standard.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before urinal installation.

B. Examine walls and floors for suitable conditions where urinals will be installed.

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

3.2 INSTALLATION

A. Urinal Installation:

1. Install urinals level and plumb according to rough-in drawings.
2. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
3. Install wall-hung, bottom-outlet urinals with tubular waste piping attached to supports.
4. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC A117.1.
5. Install trap-seal liquid in waterless urinals.

B. Support Installation:

1. Install supports, affixed to building substrate, for wall-hung urinals.

2. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
3. Use carriers without waste fitting for urinals with tubular waste piping.
4. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.

C. Flushometer-Valve Installation:

1. Install flushometer-valve water-supply fitting on each supply to each urinal.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible urinals with handle mounted on open side of compartment.
4. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."

E. Joint Sealing:

1. Seal joints between urinals and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to urinal color.
3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 PIPING CONNECTIONS

A. Connect urinals with water supplies and soil, waste, and vent piping. Use size fittings required to match urinals.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to urinals, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust urinals and controls. Replace damaged and malfunctioning urinals, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. Clean urinals and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed urinals and fittings.

C. Do not allow use of urinals for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.16

SECTION 224500 - EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1.2 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.

C. Portable, Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid supply.

D. Tepid: Between 60 and 100 deg F.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

B. Shop Drawings:

1. Plans, elevations, sections, and [mounting] [attachment] details.
2. Details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Emergency fixture third-party certification documentation.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For emergency plumbing fixtures.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ANSI/ISEA Z358.1 for emergency plumbing fixtures including third-party certification of fixtures.

B. Comply with ASSE 1071 for temperature-actuated mixing valves for plumbed emergency fixtures.

C. Comply with ASME A112.18.1/CSA B125.1 for water-supply fittings.

D. Comply with ASME A112.18.2/CSA B125.2 for plumbing waste fittings.

E. Comply with NSF 61 and NSF 372 for fixture materials that will be in contact with potable water.

F. Comply with requirements in ICC A117.1 for plumbing fixtures for people with disabilities.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SAFETY EYE/FACE WASH FIXTURE

A. Eyewash Units - Deck Mounted, Swivel Type, Plumbed:

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

a. Chicago Faucet
b. Bradley Corporation
c. Guardian Equipment Co

2. Two eye washing aerated sprayers, low pressure delivery, automatic anti-dust cover, brass construction with anti-corrosion polyamide plastic coating (yellow), horizontal swing operation ceramic disc valve, nominal flow 2.5 gpm, ANSI Z358.1 compliant.

B. TEMPERING VALVE

1. Thermostatic mixing valve, control flow over wide range of flow and pressures from the domestic cold and hot water streams.
2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Lawler

b. Bradley Corporation
c. Powers
d. Symmons

3. ANSI Z358.1 compliant.
4. ASSE 1071, IAPMO compliant
5. Lead-free brass body construction
6. Adjustable flow range
7. Integral domestic cold water bypass.
8. Operating pressure range of 10 psi to 45 psi.
9. ½” NPT inlets, outlet.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for domestic hot and cold water piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

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

3.2 INSTALLATION OF EMERGENCY PLUMBING FIXTURE

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components following manufacturer’s recommendations.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures, to facilitate maintenance of equipment. Use ball or gate valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 220523.12 "Ball Valves for Plumbing Piping.

1. Exceptions:

   a. Omit shutoff valve on supply to group of plumbing fixtures that includes emergency equipment.
   b. Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.

E. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."

F. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."

G. Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

H. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 220500 "Common Work Results for Plumbing."

I. Fill self-contained fixtures with flushing fluid.

3.3 PIPING CONNECTIONS

A. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering thermostatic mixing valve. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 221116 "Domestic Water Piping."

B. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Emergency plumbing fixtures and water-tempering thermostatic mixing valve will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports, submit to construction manager for review and approval.

3.6 ADJUSTING

A. Operate and adjust emergency plumbing fixtures and controls. Replace damaged and malfunctioning fixtures and controls.

B. Adjust or replace fixture flow regulators for proper flow, and proper temperature of 85 degrees F delivered to the sprayers.

C. Adjust equipment temperature settings.

3.7 CLEANING AND PROTECTION

A. Clean emergency plumbing fixtures with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed emergency plumbing fixtures and fittings.

C. Do not allow use of emergency plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224500

SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Quality requirements
2. Coordination Procedures
3. Testing
4. Inspections
5. Motors.
6. Alignment guides and anchors.
7. Sleeves.
8. Grout and sealants.
9. Thermometers, filled system.
10. Thermometers, liquid in glass.
11. Duct-thermometer mounting brackets.
12. Thermowells.
13. Pressure gauges, dial type.
14. Gauge attachments.

1.2 DEFINITIONS

A. Existing To Remain (ETR): Existing that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.3 ACTION SUBMITTALS

A. Refer to procedures and requirements for submittals in Division 1 specifications

B. Product Data:

1. For each type of product, excluding motors which are included in Part 1 of HVAC equipment Sections.
   a. Include construction details, material descriptions, and dimensions of individual components, and finishes.
   b. Include operating characteristics and furnished accessories.

C. Delegated Design Submittals: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing

connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

D. Sustainable Design Submittals:

1. Product Data: For sealants, indicating VOC content.
2. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter.

B. Welding certificates.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Provide work that is complete in every respect, tested and ready for operation, with equipment, components, materials and installation of the highest quality and conforming to accepted practices and standards of all mechanical trades on the project

B. Provide systems, components, equipment and materials in compliance with Ohio Mechanical Code 2017 and requirements of the Authority Having Jurisdiction (ASJ).

C. All equipment, components and appliances provided for the project shall bear the label of an approved testing agency, and installed in accordance with the manufacturer’s instructions and recommendations.

D. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.

E. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators in accordance with 2021 ASME Boiler and Pressure Vessel Code, Section IX.

1.7 COORDINATION

A. Mechanical contractor shall take responsibility for coordination of HVAC system demolition and installation with contractors of all other trades before beginning any demolition or installation work; as well as existing building elements and conditions.

1. Consult all contract drawings of all trades as may affect work of the mechanical scope.
2. Notify the construction manager immediately of any changes in equipment, locations, or conflicts which may impact a work of other contractors
3. Review all existing and new equipment electrical requirements, before ordering any equipment, and advise construction manager immediately of any changes in design or installation required for proper electrical service and wiring of equipment.

B. Mechanical contractor shall initiate development of coordination drawings and meet with all trades to facilitate a coordination drawings generation process to demonstrate multiple system coordination of all inter-disciplinary installations on the project. The process shall be conducted using electronic drafting software (AutoDesk) or BIM software, at contractor’s discretion.

1. Mechanical contractor shall begin with preliminary coordination drawings which include all mechanical equipment and elements, and plan and elevation views, coordinating with building elements such as floor to floor elevations, ceiling heights, chases, shafts, roofs and exterior elevations.
2. A preliminary coordination drawing set will be provided to all other trades for their input of their equipment and installed systems, materials.
3. Throughout the process, any conflicts shall be identified and reported to the construction manager and affected trades.
4. Mechanical contractor and affected trades shall meet to develop resolution and details for such conflicts; updating the coordination drawings accordingly.
5. Completed preliminary coordination drawings shall be reviewed and accepted by all contractors before submitting to the construction manager for final review and acceptance. Any changes necessary to the contract documents shall be approved first by the owner.
6. The coordination drawing process shall be started, managed and completed in keeping with the overall project schedule.
7. Equipment orders, material orders, installation, shall not commence until the coordination process is completed; unless otherwise approved by the construction manager

C. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.

4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 MOTORS

A. Motor Requirements, General:

1. Content includes motors for use on alternating-current power systems of up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.
2. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or other specification sections.
3. Comply with NEMA MG 1 unless otherwise indicated.
4. Comply with IEEE 841 for severe-duty motors.

B. Motor Characteristics:

1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 ft. above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. Polyphase Motors:

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Premium Efficient, as defined in NEMA MG 1.
3. Service Factor: 1.15.
4. Multispeed Motors: Variable torque.
   a. For motors with 2:1 speed ratio, consequent pole, single winding.
   b. For motors with other than 2:1 speed ratio, separate winding for each speed.
5. Rotor: Random-wound, squirrel cage.
6. Bearings: Re-greasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
7. Temperature Rise: Match insulation rating.
8. Insulation: Class F.
9. Code Letter Designation:
   a. Motors 15 Hp and Larger: NEMA starting Code F or Code G.
   b. Motors Smaller Than 15 Hp: Manufacturer's standard starting characteristic.
10. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

D. Additional Requirements for Polyphase Motors:

1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
2. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

   a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time-rise pulses produced by pulse-width-modulated inverters.
   b. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
   e. Shaft grounding rings for grounding of currents generated along shaft motor by voltage potential that can be generated by imbalances by application of variable-speed controller electronics, protecting motor bearings.

3. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

E. Single-Phase Motors:

1. Motors larger than 1/20 hp must be one of the following, to suit starting torque and requirements of specific motor application:

   a. Permanent-split capacitor.
   b. Split phase.
   c. Capacitor start, inductor run.
   d. Capacitor start, capacitor run.

2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
3. Bearings: Permanently pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. Motors 1/20 hp and Smaller: Shaded-pole type.
5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device will automatically reset when motor temperature returns to normal range.

F. Electronically Commutated Motors:

1. Microprocessor-Based Electronic Control Module: Converts 120 V or 208 V single-phase AC power to three-phase DC power to operate the brushless DC motor.
2. Three-phase power motor module with permanent magnet rotor.
3. Circuit board, or digital speed controller/LED display.
4. Building Automation System Interface: Via AC voltage signal, DC voltage signal, or Digital Serial Interface (DSI).

PART 3 - EXECUTION

3.1 INSPECTIONS

A. Provide inspections of installed work in accordance with the requirements outlined in the Division I specifications

B. Contractor shall notify the construction manager minimum of 48 hours in advance of any inspections, such that there is opportunity to witness inspections. Inspections performed without may be required to be repeated, at construction manager's discretion.

C. Do not insulate, cover, or otherwise conceal equipment items, components or materials to be inspected.

D. Submit all inspection results and reports to the Construction manager for review and acceptance promptly upon completion.

E. Provide all required inspections and obtain approvals, secure any required certificates of inspection, report forms and approvals, and maintain a copy for submission as part of the operating and maintenance manual.

3.2 TESTING

A. Provide testing of installed work in accordance with the requirements outlined in the Division I specifications

B. The mechanical contractor shall take responsibility for testing, adjustment and demonstration proper operation of all mechanical systems within the scope of this project.

C. Contractor shall notify the construction manager minimum 48 hours in advance of any testing or adjustment procedures of any installed systems or subsystems, to provide the opportunity for those procedures to be witnessed. The construction manager may, at their discretion, require test or adjustment be repeated in the presence if that opportunity is not afforded them.

D. All equipment and components are to be visually checked, tested and verified for proper finished installation, connections and functions, with all adjustments having been made to optimize performance.

E. The contractor is to provide certified factory trained technicians for start-up and testing of new equipment where called for in the individual specification sections for such equipment. Start-up and testing by local sales representative not be accepted as startup by a factory trained technician. Provide written startup procedures in advance to the construction manager for review before scheduling such factory technician startup procedures.

F. Do not insulate, cover, or otherwise conceal any equipment, components or materials to be tested or adjusted.

G. The contractor is responsible for providing all test equipment, tools, gauges, meters and personnel as may be necessary to perform tests, demonstrate integrity of the completed installation, to the approval of the Construction Manager and Authority having jurisdiction.

H. Submit all start-up, tests and adjustment procedure results, reports, completed forms to the Construction Manager for review and acceptance promptly upon their completion.

I. Provide all required start-ups, tests, adjustments and obtain approvals, secure any required certificates of completion, report forms and approvals, and maintain a copy of all completed forms and reports for inclusion in the operating and maintenance manual.

3.3 DEMONSTRATION

A. Provide demonstration and training of the installed systems and subsystems in accordance with requirements outlined in the Division I specifications.

B. The mechanical contractor is responsible for demonstrating to the construction manager that all of the HVAC systems are complete and operating properly.

C. Submit to the construction manager a proposed schedule for demonstration and training of systems, including demonstration and training documents and forms, no later than 15 business days prior to substantial completion or approval.

D. Demonstration and training shall only commence after the mechanical contractor has performed all inspections, start-ups and operational tests, complete with successful results, reports and completed startup forms.

E. Provide on-site in-service training for all systems and subsystems, including presentation of related operations and maintenance manuals, systems manuals and related training guides. A minimum of 32 hours of such training shall be provided.

F. Refer to the demonstration and training requirements specific to individual equipment and systems outlined in the specification sections or such equipment and systems.

G. Include instruction on regular maintenance and inspection procedures that are required to be followed by the owner.

H. Document completed demonstration and training on forms which shall include dates, names of participants, signed by all.

3.4 INSTALLATION OF EXPANSION JOINTS - GENERAL

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

3.5 INSTALLATION OF ALIGNMENT GUIDES AND ANCHORS

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9.
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-58, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
3. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

3.6 INSTALLATION OF PIPE LOOPS AND SWING CONNECTIONS

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.7 INSTALLATION OF SLEEVES - GENERAL

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.
    a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
3. Using grout or silicone sealant, seal space outside of sleeves in floors/slabs/walls without sleeve-seal system. Select to maintain fire resistance of floor/slab/wall.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants that joint sealant manufacturer's literature indicates is appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.8 INSTALLATION OF SLEEVES WITH WATERSTOP

A. Install sleeve with waterstop as new walls and slabs are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange centered across width of concrete slab or wall.

C. Secure nailing flanges to wooden concrete forms.

D. Using grout or silicone sealant, seal space around outside of sleeves.

3.9 INSTALLATION OF STACK-SLEEVE FITTINGS

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 3 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.10 INSTALLATION OF SLEEVE-SEAL SYSTEMS

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building, and passing through exterior walls.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.11 INSTALLATION OF METERS AND GAUGES

A. Install thermowells with socket extending a minimum of 2 inches into fluid one-third of pipe diameter or to center of pipe, and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels;

connect cases with tubing, and support tubing to prevent kinks. Use minimum tubing length.

G. Install pipe-mounted thermal-energy temperature sensors in thermowells and extend wiring to indicator.

H. Install duct-thermometer-mounting brackets in walls of ducts. Attach to duct with screws.

I. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position.

J. Install remote-mounted pressure gauges on panel.

K. Install valve and snubber in piping for each pressure gauge for fluids (except steam).

L. Install valve and syphon fitting in piping for each pressure gauge for steam.

M. Install test plugs in piping tees.

N. Install flow indicators in piping systems in accessible positions for easy viewing.

O. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

P. Install flowmeter elements in accessible positions in piping systems.

Q. Install wafer-orifice flowmeter elements between orifice-type pipe flanges.

R. Install all flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

S. Install permanent indicators on walls or brackets in accessible and readable positions.

T. Install connection fittings in accessible locations for attachment to portable indicators.

3.12 DEVICE CONNECTIONS

A. Install meters and gauges adjacent to machines and equipment to allow space for service and maintenance of meters, gauges, machines, and equipment.

3.13 DEVICE ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gauges to proper angle for best visibility.

3.14 SLEEVE INSTALLATION

A. Sleeves and Sleeve Seals:

1. Perform the following tests and inspections:

a. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

b. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

2. Prepare test and inspection reports.

B. Escutcheons:

1. Using new materials, replace broken and damaged escutcheons and floor plates.

3.15 SLEEVES APPLICATION

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above and below Grade:

a. Sleeves with waterstops.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

2. Concrete Slabs-on-Grade:

a. Sleeves with waterstops.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs above Grade:

a. Sleeves with waterstops, or stack-sleeve fittings.

4. Interior Walls and Partitions:

a. Sleeves without waterstops.

END OF SECTION 230500

SECTION 230523.12 - BALL VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Brass ball valves.
2. Stainless steel ball valves.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. RPTFE: Reinforced polytetrafluoroethylene.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, and weld ends.
3. Set ball valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. A.Y. McDonald Mfg. Co
2. American Valve, Inc
3. Apollo Valves
4. Hammond Valve
5. Jenkins Valves; a Crane Co. brand
6. Jomar Valve
7. Milwaukee Valve Company
8. Stockham; a Crane Co. brand
9. Viega LLC
10. WATTS; A Watts Water Technologies Company

2.2 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on steel valves.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for cast copper solder-joint connections.
6. ASME B16.22 for wrought copper and copper alloy solder-joint connections.
7. ASME B16.34 for flanged and threaded end connections.
8. ASME B31.1 for power piping valves.
9. ASME B31.9 for building services piping valves.

B. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

C. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

D. Valve Sizes: Same as upstream piping unless otherwise indicated.

E. Valve Actuator Types:

1. Hand Lever: For quarter-turn valves smaller than NPS 4.

F. Valves in Insulated Piping:

1. Provide 2-inch extended neck stems.
2. Extended operating handles with nonthermal-conductive covering material, and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.3 STAINLESS STEEL BALL VALVES

A. Bronze Ball Valves, Solid stainless steel ball and trim, Two Piece with Full Port, Threaded or Flanged Ends:

1. Standard: MSS SP-110.
2. CWP Rating: 200 psig.
3. Body Design: Split body.
4. Body Material: Cast bronze.
5. Ends: Threaded or flanged.
6. Seats: PTFE.
7. Stem: Type 316 stainless steel.
8. Ball: Type 316 stainless steel.
9. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow space for service, maintenance, and equipment removal without system shutdown.

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full valve actuation movement.

F. Valve Tags: Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

G. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's recommended maximum.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves exhibiting leakage.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified SWP classes or CWP ratings are unavailable, provide the same types of valves with higher SWP classes or CWP ratings.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Smaller: bronze ball valves, two piece, with stainless steel ball and trim, full port, and threaded or solder joint ends.

3.6 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Smaller: bronze ball valves, two piece, with stainless steel ball and trim, full port, and threaded or solder joint ends.

END OF SECTION 230523.12

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Equipment stands.
7. Equipment supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating postconsumer and pre-consumer recycled content and cost.
2. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.
3. Product Certificates: For indigenous materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each indigenous material.
4. Environmental Product Declaration: For each product.
5. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each regional material.
6. Third-Party Certifications: For each product.
7. Third-Party Certified Life Cycle Assessment: For each product.

C. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.

4. Equipment supports.

D. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Division 1 specification sections for Quality Requirements, to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

C. Manufacturer of hangers and supports:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following that may be incorporated into the Work include, but are not limited to, the following:
2. Anvil International/Smith-Cooper International; Tailwind Capital, LLC
3. CADDY; brand of nVent Electrical plc

4. Carpenter & Paterson, Inc
5. Empire Industries, Inc.
6. MIRO Industries
7. PHD Manufacturing, Inc
8. RectorSeal HVAC

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Adjustable band type hangers, type 10, MSS-SP-69.
3. Galvanized Metallic Coatings: Pre-galvanized, hot-dip galvanized, or electro-galvanized.
4. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
5. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel or stainless steel.

B. Stainless Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel or stainless steel.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

1. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channels: Continuous slotted carbon-steel channel with inturned lips.

4. Channel Width: Select for applicable load criteria.
5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel or stainless steel.
7. Metallic Coating, Hot-dip galvanized.
8. Paint Coating: Green epoxy, acrylic, or urethane.

2.5 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psi, ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi, minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

A. Reversible beam clamps of malleable iron with electro-galvanized finish, locking nut and retaining strap for retrofit application, MSS-Sp-69, UL listed.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: Zinc-coated or stainless steel.
2. Outdoor Applications: Stainless steel.

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.8 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.

F. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Provide adjustable band hangers for piping exposed to public view, nut and threaded rod on top, paint ready finish.

C. Provide padded clevis type hangers for insulated piping where exposed to public view, nut and threaded rod on top, paint ready finish.

D. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe

size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.

2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

E. Install hangers and attachments as required to properly support piping from building structure.

F. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.

G. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

H. Fastener System Installation:

1. Powder-actuated fasteners will not be acceptable for this project
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

I. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

J. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

K. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

L. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

M. Install lateral bracing with pipe hangers and supports to prevent swaying.

N. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

O. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

P. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

Q. Insulated Piping:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Thermal-hanger shield inserts may be used as an option. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Thermal-hanger shield inserts may be used as an option. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 INSTALLATION OF EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers, and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touchup:

1. Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   a. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
2. Comply with requirements in Division 9 for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
3. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers, and metal framing systems, and attachments for general service applications.

F. Use stainless steel pipe hangers and stainless steel attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
4. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
5. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated, stationary pipes NPS 3/4 to NPS 8.
6. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 2.
7. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 2.
8. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
9. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8.
10. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3.

11. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
11. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.

b. Medium (MSS Type 32): 1500 lb.

12. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
13. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
14. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
4. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
5. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

END OF SECTION 230529

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Warning tape.
4. Pipe labels.
5. Duct labels.
6. Valve tags.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment-Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve-numbering scheme.

E. Valve Schedules: Provide for each piping system. Include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.
2. Letter and Background Color: As indicated for specific application under Part 3.
3. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

6. Fasteners: Stainless steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.

B. Letter and Background Color: As indicated for specific application under Part 3.

C. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.

D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

F. Fasteners: Stainless steel rivets or self-taping screws.

G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

H. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA70E and other applicable codes and standards.

I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 WARNING TAPE

A. Material: Vinyl.

B. Minimum Thickness: 0.005 inch.

C. Letter, Pattern, and Background Color: As indicated for specific application under Part 3.

D. Waterproof Adhesive Backing: Suitable for indoor or outdoor use.

E. Maximum Temperature: 160 deg F.

F. Minimum Width: 2 inches.

2.4 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.

B. Letter and Background Color: As indicated for specific application under Part 3.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover or fully cover circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:

1. Pipe size.
2. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
3. Lettering Size: Size letters in accordance with ASME A13.1 for piping, at least 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances.

2.5 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter and Background Color: As indicated for specific application under Part 3.

C. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

F. Fasteners: Stainless steel rivets or self-tapping screws.

G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

H. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings. Also include the following:

1. Duct size.
2. Flow-Direction Arrows: Include flow-direction arrows on main distribution ducts. Arrows may be either integral with label or may be applied separately.
3. Lettering Size: size letters in accordance with ASME A13.1 for piping, at least 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances.

2.6 DUCT MARKERS

A. Product from one of the following available manufacturers, though not limited to, the following:

1. Seton
2. MSI
3. Clarion
4. Brady

B. Pressure-sensitive, self-adhesive backed labels, minimum .127 mm thick gloss vinyl.

C. Compliant with ANSI A13.1 standard

D. Tack, adhesion, minimum 850 g (ASTM 2979)

E. Custom printed for service, unit, flow direction.

F. Minimum 2-1/4 inch tall, minimum 1-1/2” tall characters.

2.7 VALVE TAGS

A. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: stainless steel, 0.024-inch or aluminum, 0.031-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire, link chain, beaded chain, or S-hook.

B. Letter and Background Color: As indicated for specific application under Part 3.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Include valve-tag schedule in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 INSTALLATION, GENERAL REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Where identification is to be provided for piping, ducts or other system components visible to the occupants in finished spaces, position labels, tags, signage, tapes, near top side to make them less noticeable to occupants.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

E. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

A. Permanently fasten labels on each item of mechanical equipment.

B. Sign and Label Colors:

1. White letters on an ANSI Z535.1 safety-blue background.

C. Locate equipment labels where accessible and visible.

3.4 INSTALLATION OF WARNING TAPE

A. Warning Tape Color and Pattern: Yellow background with black diagonal stripes color, marking pattern, text.

B. Install warning tape on pipes and ducts, with cross-designated walkways providing less than 6 ft. of clearance.

C. Locate tape so as to be readily visible from the point of normal approach.

3.5 INSTALLATION OF PIPE LABELS

A. Piping Color Coding: Painting of piping is specified in Division 9

B. Install pipe labels showing service and flow direction with permanent adhesive on pipes.

C. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Within 3 ft. of each valve and control device.
2. At access doors, manholes, and similar access points that permit view of concealed piping.
3. Within 3 ft. of equipment items and other points of origination and termination.
4. Spaced at maximum intervals of 25 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping, ductwork, and equipment.

D. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.

E. Flow-Direction Arrows: Use arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

F. Pipe-Label Color Schedule:

1. Chilled-Water Piping: White letters on an ANSI Z535.1 safety-green background.
2. Heating Water Piping: White letters on an ANSI Z535.1 safety-green background
3. Natural Gas: Black letters on an ANSI Z535.1 safety-yellow background.
4. Potable and Other Water: White letters on an ANSI Z535.1 safety-green background.

3.6 INSTALLATION OF DUCT LABELS

A. Install plastic-laminated duct labels showing service and flow direction with permanent adhesive on air ducts.

1. Provide labels in the following color codes:

   a. For air supply ducts: White letters on blue background.
   b. For air return ducts: White letters on blue background.
   c. For exhaust-, outside-, relief-, return-, and mixed-air ducts: White letters on blue background.

B. Stenciled Duct-Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.

1. For all air ducts: Black letters on white background

C. Locate label near each point where ducts enter into and exit from concealed spaces and at maximum intervals of 20 ft. where exposed or are concealed by removable ceiling system.

3.7 INSTALLATION OF VALVE TAGS

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule in the operating and maintenance manual.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below.

1. Valve-Tag Size and Shape:
    a. Chilled Water: 1-1/2 inches, round or square.
    b. Hot Water: 1-1/2 inches, round or square.
    c. Gas: 1-1/2 inches, round or square
2. Valve-Tag Colors:
    a. For each piping system, use the same lettering and background coloring system on valve tags as used for the Pipe Label Schedule text and background.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Testing, Adjusting, and Balancing of Air Systems:
   a. Constant-volume air systems.
   b. Variable-air-volume systems.
2. Testing, Adjusting, and Balancing of Hydronic Piping Systems:
   a. Constant-flow hydronic systems.
   b. Variable-flow hydronic systems.
   c. Primary-secondary hydronic systems.
3. Testing, adjusting, and balancing of equipment.
4. Testing, adjusting, and balancing of existing HVAC systems and equipment.
5. Procedures for exhaust hoods.
6. Sound tests.
7. Duct leakage tests verification.
8. Pipe leakage tests verification.
9. HVAC-control system verification.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. AHJ: Authority Having Jurisdiction

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

E. TABB: Testing, Adjusting, and Balancing Bureau.

F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

G. TDH: Total dynamic head.

1.3 TAB SPECIALISTS

A. Subject to compliance with these requirements, and owner approval, engage a TAB firm specializing in the work of this section; and that is a firm independent of the installing contractor.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: Conduct a TAB conference at the site after approval of the TAB strategies and procedures plan, to develop a mutual understanding of the details. Provide a minimum of 14 days advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Needs for coordination and cooperation of trades and subcontractors.
d. Proposed procedures for documentation and communication flow.

1.5 ACTION SUBMITTALS

A. Submit for review and approval proposed independent TAB firm, and assigned team members. Prepare and submit within 1 week from notice to proceed.

B. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

C. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.

D. Strategies and Procedures Plan: Within 45 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.

E. System Readiness Checklists: Within 45 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.

F. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

G. Certified TAB reports.

H. Sample report forms.

I. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.6 QUALITY ASSURANCE

A. Provide the services of an independent TAB firm to perform Testing, Adjusting and Balancing for the project.

B. TAB Specialists Qualifications, Certified by AABC:

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC.

C. TAB Specialists Qualifications, Certified by NEBB or TABB:

1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

1. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

F. Code and AHJ Compliance: TAB is required to comply with Ohio Building Code 2017, and governing codes and requirements of authorities having jurisdiction.

G. Third Party Operational Testing: The Owner is to engage, through the General Contractor, an independent commissioning service provider, who will generate a plan and List of Functional Tests for HVAC systems, some of which will include repeating verification of TAB (referencing paragraph 3.22 of this section). The independent commissioning service provider will self-perform all tests; however, this contractor for TAB is to provide review of that Functional Tests List, with written comment, to be returned to the General Contractor (within 15 days of receipt).

1.7 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations. Refer to the phasing plans in the project drawings.

B. Partial Owner Occupancy: Owner will occupy temporarily, pre-identified portions of the building, and will move into and occupy other completed areas of building before Substantial Completion of the entire project. Plan work accordingly and cooperate closely with the project manager and Owner during TAB operations to minimize conflicts with Owner's operations. Refer to the phasing plans in the project drawings.

PART 2 - PRODUCTS (Not Applicable)
PART 3 - EXECUTION

3.1 TAB SPECIALISTS

A. Subject to compliance with requirements, and owner approval, engage the TAB firm for planning and pre-installation meeting before beginning any installation of new systems.

3.2 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums used for HVAC to verify that they are properly separated from adjacent areas and sealed.

F. Examine equipment performance data, including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.

L. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

Q. Report, to the construction manager, in writing, deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

   a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
   b. Duct systems are complete with terminals installed.
   c. Volume, smoke, and fire dampers are open and functional.
   d. Clean filters are installed.
   e. Fans are operating, free of vibration, and rotating in correct direction.
   f. Variable-frequency controllers' startup is complete and safeties are verified.
   g. Automatic temperature-control systems are operational.

h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
b. Piping is complete with terminals installed.
c. Water treatment is complete.
d. Systems are flushed, filled, and air purged.
e. Strainers are pulled and cleaned.
f. Control valves are functioning in accordance with the sequence of operation.
g. Shutoff and balance valves have been verified to be 100 percent open.
h. Pumps are started and proper rotation is verified.
i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in AABC's "National Standards for Total System Balance", ASHRAE 111, NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", and in this Section.

B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
4. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.5 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:

1. Motors.
2. Pumps.
3. Fans and ventilators.
4. Terminal units.
5. Boilers.
6. Unit heaters.
7. Water chillers.
8. Air-handling units.
9. Rooftop air-conditioning units.
10. Coils.
11. Fan coil units.
12. Unit ventilators.
13. Ductless heat pump.

3.6 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' Record drawings duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

   a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
   b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
   c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
   d. Adjust controls so that terminal is calling for minimum airflow.
   e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
   f. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer. Series fan powered terminals will include ECM fan motors and factory adjustment knob on unit housing for speed setting.

   a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
   b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow, so that connected total matches fan selection and simulates actual load in the building.
   c. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
   d. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

6. Measure fan static pressures as follows:
   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report any artificial loading of filters at the time static pressures are measured.
7. Set final return, exhaust/relief and outside airflows to the fan(s) while operating at maximum return airflow and minimum outdoor airflow.
   a. Balance the return-air ducts and inlets.
   b. Verify that terminal units are meeting design airflow under system maximum flow.
8. Re-measure the inlet static pressure at the most critical terminal unit, and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls Contractor.
9. Verify final system conditions as follows:
   a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
   b. Re-measure and confirm that total airflow is within design.
   c. Re-measure final fan operating data, speed, volts, amps, and static profile.
   d. Mark final settings.
10. Repeat the process for testing, adjusting and balancing the system in the economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data. Verify tracking between supply and return fans.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and equipment flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' Record drawings piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
   1. Check expansion tank for proper setting.
   2. Check highest vent for adequate pressure.
   3. Check flow-control valves for proper position.
   4. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.

5. Verify that motor controllers are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

D. Measure and record upstream and downstream pressure of each piece of equipment.

E. Measure and record upstream and downstream pressure of pressure-reducing valves.

F. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

1. Check settings and operation of each safety valve. Record settings.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two-way and minimum flow bypass control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the pressure-differential sensor(s) is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no flow diversity:

1. Adjust pumps to deliver total design flow.

   a. Measure total water flow.

      1) Position valves for full flow through coils.
      2) Measure flow by main flow meter, if installed.
      3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

   b. Measure pump TDH as follows:

      1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
      2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
      3) Convert pressure to head and correct for differences in gauge heights.
      4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
      5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

   c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

    a. Measure flow in main and branch pipes.
    b. Adjust main and branch balance valves for design flow.
    c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

    a. Measure flow at terminals.
    b. Adjust each terminal to design flow.
    c. Re-measure each terminal after it is adjusted.
    d. Position minimum flow bypass control valves and adjust to maintain design minimum flows.
    e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

    a. Measure differential pressure and verify that it is within manufacturer's specified range.
    b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

    a. Measure and balance coils by either coil pressure drop or temperature method.
    b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system pressure-differential set point(s).
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:

    a. Re-measure and confirm that total flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
    c. Mark final settings.

D. For systems with flow diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by Architect.

3. Adjust pumps to deliver total design flow.
    a. Measure total water flow.
        1) Position valves for full flow through coils.
        2) Measure flow by main flow meter, if installed.
        3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
    b. Measure pump TDH as follows:
        1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
        2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
        3) Convert pressure to head and correct for differences in gauge heights.
        4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
        5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.
    c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
4. Adjust flow-measuring devices installed in mains and branches to design water flows.
    a. Measure flow in main and branch pipes.
    b. Adjust main and branch balance valves for design flow.
    c. Re-measure each main and branch after all have been adjusted.
5. Adjust flow-measuring devices installed at terminals for each space to design water flows.
    a. Measure flow at terminals.
    b. Adjust each terminal to design flow.
    c. Re-measure each terminal after it is adjusted.
    d. Position minimum bypass control valves to maintain design minimum flows.
    e. Perform temperature tests after flows have been balanced.
6. For systems with pressure-independent valves at terminals:
    a. Measure differential pressure, and verify that it is within manufacturer's specified range.
    b. Perform temperature tests after flows have been verified.
7. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system pressure-differential set point(s).
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:

a. Re-measure and confirm that total water flow is within design.
b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
c. Mark final settings.

3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first, assure final flow rate meets boiler manufacturer’s recommendations.

B. Balance the secondary circuits after the primary circuits are complete.

C. Adjust pumps to deliver total design flow.

1. Measure total water flow.

a. Position valves for full flow through coils.
b. Measure flow by main flow meter, if installed.
c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
d. Establish pump manufacturer minimum flow in heating hot water secondary loop system for each/both heating hot water system pumps.

2. Measure pump TDH as follows:

a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
c. Convert pressure to head and correct for differences in gauge heights.
d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and

verify that the pump has the intended impeller size.

e. With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

D. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

E. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position minimum flow bypass control valves to maintain design flow minimums.
5. Perform temperature tests after flows have been balanced.

F. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

G. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

H. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
3. Mark final settings.

I. Verify that memory stops have been set.

3.11 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.12 PROCEDURES FOR WATER CHILLERS

A. Air-Cooled Chillers: Balance water flow through each evaporator to within specified tolerances of indicated flow, with all pumps operating. With only one chiller operating in a multiple-chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
3. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
4. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
5. Capacity: Calculate in tons of cooling.
6. Efficiency: Calculate operating efficiency for comparison to submitted equipment.
7. Verify condenser-fan rotation and record fan and motor data, including number of fans and entering- and leaving-air temperatures.
8. Establish chiller manufacturer minimum flow in chilled water system and through chiller.
9. Make adjustment in minimum flow bypass control valves to establish minimum chilled water flow through chiller evaporator in accordance with chiller manufacturer recommendation in all operating conditions; coordinate with the temperature controls contractor to calibrate and confirm accurate reading and response for flow meters.

3.13 PROCEDURES FOR AIR-COOLED CONDENSING UNITS AND HEAT PUMPS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of compressor(s), fan(s), and motors.

3.14 PROCEDURES FOR BOILERS

A. Hydronic Boilers:

1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Measure and record pressure drop.
4. Measure and Record relief valve(s) pressure setting.
5. Capacity: Calculate in Btu/h of heating output.
6. Fuel Consumption: If boiler fuel supply is equipped with flow meter, measure and record consumption.
7. Establish boiler manufacturer minimum flow in primary loop and through each/both boilers.
8. Efficiency: Calculate operating efficiency for comparison to submitted equipment.
9. Fan, motor, and motor controller operating data.

3.15 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each hydronic coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Entering and leaving refrigerant pressure and temperatures.

3.16 DUCT LEAKAGE TESTS

A. Witness the duct leakage testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.17 PIPE LEAKAGE TESTS

A. Witness the pipe pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.18 HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify HVAC control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.19 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent. If design value is less than 100 cfm, within 10 cfm.
2. Air Outlets and Inlets: Plus 10 percent or minus 10 percent, If design value is less than 100 cfm, within 10 cfm.
3. Heating-Water Flow Rate: Plus or minus 5 percent.
4. Chilled-Water Flow Rate: Plus or minus 5 percent

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.20 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance-measuring and -balancing devices.

B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.21 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents, including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract

Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans performance forms, including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Heating coil, dry-bulb conditions.
    e. Face and bypass damper settings at coils.
    f. Fan drive settings, including settings and percentage of maximum pitch diameter.
    g. Variable-frequency controller settings for variable-air-volume systems.
    h. Settings for pressure controller(s).
    i. Other system operating conditions that affect performance.
16. Test conditions for pump performance forms, including the following:
    a. Variable-frequency controller settings for variable-flow hydronic systems.
    b. Settings for pressure controller(s).
    c. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram produced with electronic drafting software (AutoDesk) and include the following:
    1. Quantities of outdoor, supply, return, and exhaust airflows.
    2. Water and steam flow rates.
    3. Duct, outlet, and inlet sizes.
    4. Pipe and valve sizes and locations.
    5. Terminal units.
    6. Balancing stations.
    7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units, include the following:
    1. Unit Data:
        a. Unit identification.
        b. Location.
        c. Make and type.
        d. Model number and unit size.
        e. Manufacturer's serial number.
        f. Unit arrangement and class.
        g. Discharge arrangement.
        h. Sheave make, size in inches, and bore.
        i. Center-to-center dimensions of sheave and amount of adjustments in

inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and speed.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan speed.
d. Inlet and discharge static pressure in inches wg.
e. For each filter bank, filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. List for each internal component with pressure-drop, static-pressure differential in inches wg.
j. Outdoor airflow in cfm.
k. Return airflow in cfm.
l. Outdoor-air damper position.
m. Return-air damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.

c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

G. Gas- Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and speed.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.

l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

3. Test Data (Indicated and Actual Values):

a. Heat output in Btu/h.
b. Airflow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in deg F.
e. Leaving-air temperature in deg F.
f. Voltage at each connection.
g. Amperage for each phase.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and speed.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan speed.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

    a. System fan and air-handling-unit number.
    b. Location and zone.
    c. Traverse air temperature in deg F.
    d. Duct static pressure in inches wg.
    e. Duct size in inches.
    f. Duct area in sq. ft..
    g. Indicated airflow rate in cfm.
    h. Indicated velocity in fpm.
    i. Actual airflow rate in cfm.
    j. Actual average velocity in fpm.
    k. Barometric pressure in psig.

J. Air-Terminal-Device Reports:

1. Unit Data:

    a. System and air-handling unit identification.
    b. Location and zone.
    c. Apparatus used for test.
    d. Area served.
    e. Make.
    f. Number from system diagram.
    g. Type and model number.
    h. Size.
    i. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):

    a. Airflow rate in cfm.
    b. Air velocity in fpm.
    c. Preliminary airflow rate as needed in cfm.
    d. Preliminary velocity as needed in fpm.
    e. Final airflow rate in cfm.
    f. Final velocity in fpm.
    g. Space temperature in deg F.

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

    a. System and air-handling-unit identification.
    b. Location and zone.
    c. Room or riser served.
    d. Coil make and size.
    e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

L. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump speed.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

M. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.

c. Application.
d. Dates of use.
e. Dates of calibration.

3.22 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Construction Manager.

B. Construction Manager shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 20 percent of the total measurements checked during the final inspection, the TAB shall be considered incomplete and shall be rejected.

E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes shall be tracked to show changes made to previous report.
2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.

F. Prepare test and inspection reports.

3.23 ADDITIONAL TESTS

A. After 120 days from date of accepted completion of TAB, perform additional TAB, repeating the field procedures for the completed and installed systems from the initial field procedures to verify that balanced conditions are being maintained throughout, and to provide correction of unusual or dis-satisfactory conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Related Requirements:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct liners.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. Sustainable Design Submittals:

1. Product Data: For adhesives, indicating VOC content.
2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
3. Product Data: For coatings, indicating VOC content.
4. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.
5. Product Data: For sealants, indicating VOC content.
6. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.

3. Detail application of field-applied jackets.
4. Detail application at linkages and control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and leak testing of ductwork. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed on the project; Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. CertainTeed; SAINT-GOBAIN
   b. Johns Manville; a Berkshire Hathaway company
   c. Knauf Insulation
   d. Manson Insulation Inc.
   e. Owens Corning

2.2 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials are to be applied.

B. Products do not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.

F. Glass-Fiber Blanket: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 450 deg F in accordance with ASTM C411. Comply with ASTM C553, Type II, and ASTM C1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article. Thermal performance minimum k-value of .24 (btu-in/hr-sf) at 75F differential.

G. Glass-Fiber Board Insulation: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F and 250 deg F for jacketed and between 35 deg F and 450 deg F for unfaced in accordance with ASTM C411. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article. Thermal performance minimum k value of .24 (btu-in/hr-sf) at 75F.

H. Thermal inserts at duct hangers: Insulation inserts to prevent crushing of externally applied insulation, ASTM C591 Grade 1 polyisocyanurate, minimum 125 psi compression strength, full depth of insulation, full length of hanger, extended beyond hanger shield 2 inches in each direction.

2.3 ADHESIVES

A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS AND COATINGS

A. Materials are compatible with insulation materials, jackets, and substrates.

1. VOC Content: 300 g/L or less.

B. Vapor-Retarder Mastic, Water Based, Interior Use: Suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
4. Color: White

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Color: White.

2.5 LAGGING ADHESIVES

A. Lagging Adhesives: Comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.

1. Adhesives shall have a VOC content of 50 g/L or less.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Materials are compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.
5. Sealant shall have a VOC content of 420 g/L or less.

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.
6. ASJ+: All-service jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
7. PSK Jacket: Aluminum foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.8 FIELD APPLIED JACKETS

A. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled, roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Adhesive: As recommended by jacket material manufacturer.
2. Color: White.
3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

4. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

B. Aluminum, Corrugated or stucco embossed, 0.024 inch thick.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

1. Width: 3 inches.
2. Thickness:6.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Width: 2 inches
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

2.10 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC in accordance with ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum in accordance with ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel in accordance with ASTM A240/A240M, Type 304.

2.11 FIELD APPLIED REMOVEABLE JACKETS

A. Custom ordered and fabricated by manufacturer specializing in fabrication of custom removeable insulating blankets, minimum 1” mechanically bonded fiberglass insulation of minimum 10 pcf density, sound barrier acoustic insulation with noise reduction at 1” equivalent to NRC .75, silicone impregnated outer cover finish of white color, UL listed. Jacket of sewn construction with ribbon trim fit tight to required openings for air intake filter, coil piping connections, controls panel access, inlet and outlet ductwork, straps to secure tight to unit, held with Velcro, buttons or snaps.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents, unless otherwise approved by the engineer-of-record.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inch o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Section 078413 "Penetration Firestopping."

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF GLASS-FIBER AND MINERAL-WOOL INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

B. Comply with manufacturer's written installation instructions.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation

surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

C. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not over-compress insulation during installation.
    e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation

surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of ducts. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.7 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 9 sections for interior painting.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

   a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless steel jackets.

3.8 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior, though minimum of 15 feet from exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior, though minimum of 15 feet from exterior.
7. Outdoor, concealed supply and return.
8. Outdoor, exposed supply and return.
9. Outdoor air intake plenum.

B. Items Not Insulated:

1. Double wall ducts with interstitial insulation
2. Insulated flexible duct
3. Factory-insulated cabinets, access panels and doors.

3.10 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, supply-air duct insulation:

1. Glass-Fiber Blanket: 1-1/2 inches thick and 3 lb/cu. ft. nominal density.
2. Round, flat-oval, rectangular, up to 30” wide duct
3. Duct with dimension over 30”; Glass-Fiber Board: 1-1/2 inches and 3 lb/cu. ft. nominal density

B. Concealed, return-air duct insulation:

1. Glass-Fiber Blanket: 1-1/2 inches thick and 1.5 lb/cu. ft. nominal density.
2. Round, flat oval, rectangular, up to 30” wide duct
3. Duct with dimension over 30”; Glass-Fiber Board: 1-1/2 inches and 3 lb/cu. ft. nominal density

C. Concealed, exhaust-air duct insulation:

1. Glass-Fiber Blanket: 1-1/2 inches thick and 1.5 lb/cu. ft. nominal density.
2. Round, flat oval, rectangular
3. Sections within 15 ft run of exterior of building

D. Concealed, high velocity exhaust-air duct insulation (laser exhaust):

1. Glass-Fiber Blanket: 1-1/2 inches thick and 1.5 lb/cu. ft. nominal density.
2. Entire length including where exposed to view indoors.

E. Exposed, supply-air duct insulation:

1. Glass-Fiber Board: 1-1/2 inches thick and 3 lb/cu. ft. nominal density; for rectangular and flat-oval.
2. Glass-Fiber Pipe and Tank: 1-1/2 inches thick, 3 lb/cuft nominal density; for round ducts.

F. Exposed, return-air duct insulation:

1. Glass-Fiber Board: 1-1/2 inches thick and 2 lb/cu. ft. nominal density; rectangular and flat-oval.
2. Round, flat-oval, rectangular, up to 30” wide duct
3. Glass-Fiber Pipe and Tank: 1-1/2 inches thick, 2 lb/cuft nominal density; round ducts..

G. Exposed, outdoor-air duct insulation:

1. Glass-Fiber Board: 1-1/2 inches thick and 3 lb/cu. ft. nominal density; for rectangular and flat-oval.
2. Glass-Fiber Pipe and Tank: 1-1/2 inches thick, 3 lb/cuft nominal density; for round ducts.
3. Plenum behind louver: Glass-Fiber Board: 2 inches thick and 3 lb/cu. ft. nominal density.

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Exposed insulated ducts in view:

1. PVC, 30 mils thick.

D. Exposed insulated ducts and plenums in mechanical rooms
   1. Aluminum, 0.024 inch thick.

END OF SECTION 230713

SECTION 230716 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating HVAC equipment that is not factory insulated.

B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230719 "HVAC Piping Insulation."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied, if any).

B. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
2. Product Data: For sealants, indicating VOC content.
3. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail removable insulation at equipment connections.
2. Detail application of field-applied jackets.
3. Detail application at linkages of control devices.
4. Detail field application for each equipment type.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program[, certified by the Department of Labor, Bureau of Apprenticeship and Training].

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include, the name of the manufacturer, fabricator, type, description, and size[, as well as ASTM standard designation, and maximum use temperature].

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. CertainTeed; SAINT-GOBAIN

2. Johns Manville; a Berkshire Hathaway company
3. Knauf Insulation
4. Manson Insulation Inc
5. Owens Corning

2.2 INSULATION MATERIALS

A. Comply with requirements in "Indoor Equipment Insulation Schedule" articles for where insulating materials are applied.

B. Products do not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

E. Glass-Fiber Blanket: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 450 deg F in accordance with ASTM C411. Comply with ASTM C553, Type II, and ASTM C1290, Type II, with factory-applied vinyl jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

F. Glass-Fiber, Pipe and Tank: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F and 850 deg F, in accordance with ASTM C411. Comply with ASTM C1393.

1. Semirigid board material with factory-applied ASJ jacket.
2. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.3 ADHESIVES

A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Adhesive: As recommended by mineral fiber manufacturer and with a VOC content of 80 g/L or less.

C. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Adhesive: As recommended by Adhesive - PVC Jacket manufacturer and with a VOC content of 50 g/L or less.

2.4 MASTICS AND COATINGS

A. Materials are compatible with insulation materials, jackets, and substrates.

1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor and outdoor use on below-ambient services.

1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
2. Service Temperature Range: [0 to plus 180 deg F.
3. Color: White.

2.5 LAGGING ADHESIVES

A. Lagging Adhesives: Adhesives comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.

1. Adhesive shall be as recommended by insulation manufacturer and shall have a VOC content of 50 g/L or less.
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
3. Service Temperature Range: 20 to plus 180 deg F.
4. Color: White.

2.6 SEALANTS

A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:

1. Permanently flexible, elastomeric sealant.
2. Service Temperature Range: Minus 58 to plus 176 deg F.
3. Color: White or gray.
4. Sealant shall have a VOC content of 420 g/L or less.

2.7 FACTORY-APPLIED JACKETS

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing;

complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
4. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets comply with ASTM C1136, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. Aluminum, Corrugated or stucco embossed, 0.024 inch thick.

D. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Adhesive: As recommended by jacket material manufacturer.
2. Color: White or color as selected by Architect.
3. Factory-fabricated tank heads and tank side panels.

2.9 CORNER ANGLES

A. PVC Corner Angles: 30-mils- thick, minimum 1- by 1-inch PVC in accordance with ASTM D1784, Class 16354-C, white or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040-inch thick, minimum 1- by 1-inch aluminum in accordance with ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless Steel Corner Angles:[0.024-inch thick, minimum 1- by 1-inch stainless steel in accordance with ASTM A240/A240M, Type 304.

2.10 REMOVABLE INSULATION UNITS

A. Factory custom fabricated, sewn construction, built to order; field measured for specific application and items to be insulated. Three layer insulating cover, pliable and easily removable and easily replaceable without degradation to the cover or its fasteners. ISO 9001 2015 certified, rated to 500F.

1. Silicone impregnated, Teflon reinforced fiberglass outer layer protective cover with smooth finish, in grey or other manufacturer standard color, with teflon-coated fiberglass adhered to the interior side of the cover.
2. Silicone impregnated fiberglass interior layer to fit tight to surfaces and contours of equipment to be insulated; with teflon-coated fiberglass adhered to the interior

side of the cover.

3. Fiberglass fill between layers, 1 inch thickness minimum to provide minimum R-value of 6. Cutouts, flaps and closures to fully enclose equipment and maximize thermal coverage, held in position with fasteners which include buckles, draw cords, lacing wires.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range of between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, and jackets, of thicknesses required for each item of equipment, as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents[, unless otherwise approved by the engineer-of-record].

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is required for equipment and tanks for services below ambient temperature, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 2 inches o.c.
4. For below-ambient services, apply vapor-barrier mastic over staples.
5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

O. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Glass-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive, anchor pins, and speed washers.

1. Apply adhesives in accordance with manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints and 16 inches o.c. in both directions.
   d. Do not compress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of

tanks and vessels.

f. Impale insulation over anchor pins, and attach speed washers.

g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable and replaceable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

3.5 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:

1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. 33-1/2-inch-circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.6 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

   a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless steel jackets.

3.7 FIELD QUALITY CONTROL

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

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to one location(s) for each type of equipment defined in "Indoor Equipment Insulation Schedule" and "Outdoor, Aboveground Equipment Insulation Schedule" articles. For large equipment, remove only a portion adequate to determine compliance.

E. All insulation applications will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.8 EQUIPMENT INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. Acceptable insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials is Contractor's option.

3.9 INDOOR EQUIPMENT INSULATION SCHEDULE

A. Insulate indoor and outdoor equipment that is not factory insulated.

B. Heating-hot-water pumps insulation:

1. Glass-Fiber Board: 2 inches thick and 2 lb/cu. Ft nominal density.
2. Glass-Fiber Pipe and Tank: 2 inches thick.
3. Custom fabricated removable jacket unit, fiberglass.

C. Chilled-water pumps insulation:

1. Glass-Fiber Board: 2 inches thick and 2 lb/cu. Ft nominal density.
2. Glass-Fiber Pipe and Tank: 2 inches thick.

D. Heating-hot-water expansion/compression tank insulation is one of the following:

1. Glass-Fiber Board: 2 inches thick and 2 lb/cu. Ft nominal density.
2. Glass-Fiber Pipe and Tank: 2 inches thick.
3. Mineral Wool Pipe and Tank: 2 inches thick.

3.10 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Pump Bodies: Aluminum, Corrugated or Stucco Embossed 0.020 inch thick.

D. Tanks and vessels:

1. PVC: 30 mils thick.
2. Aluminum, Corrugated or Stucco Embossed 0.020 inch thick.

END OF SECTION 230716

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes commissioning process requirements for the following HVAC systems, assemblies, and equipment:

1. Air Handling Units
2. Packaged Roof-top Units
3. Pumps and hydronic specialties
4. Exhaust fans
5. Existing Boilers
6. Existing Chillers
7. Air terminal units
8. Cabinet heaters and unit heaters
9. Ductless split system cooling
10. Ductwork and air devices
11. Hydronic piping and distribution
12. Building Automation System (BAS).
13. TAB verification.

B. Related Requirements:

1. Section 019113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
2. For construction checklists, comply with requirements in various Division 23 Sections specifying HVAC and BAS systems, system components, equipment, and products.

1.2 DEFINITIONS

A. BAS: Building automation system.

B. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."

C. CxA (CXA): Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."

D. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they mean "as-built" systems, assemblies, sub-systems, equipment, and components.

E. TAB: Testing, adjusting, and balancing.

1.3 INFORMATIONAL SUBMITTALS

A. Submit for review, to the Construction Manager, minimum 15 days from notice to proceed.

B. Qualification Data: For commissioning manager and commissioning/testing technicians.

C. Construction Checklists:

1. Draft Commissioning plan, including draft construction checklists, and functional performance checklists, to be prepared by CxA under Section 019113 "General Commissioning Requirements." Div. 23 Subcontractor is to review Construction Checklist in accordance with requirements in Section 019113 "General Commissioning Requirements" and ASHRAE 202 and to resolve any issues with the CxA.
2. Commissioning plan, including material, installation, and functional performance checklists for systems, assemblies, subsystems, equipment, and components relating to HVAC and BAS to be part of the Cx process and in accordance with requirements in Section 019113 "General Commissioning Requirements and ASHRAE 202."

D. Test Equipment and Instruments: For all test equipment and instruments to be used in conducting Cx tests by the CxA, provide the following:

1. Equipment/instrument identification number.
2. Planned Cx application or use.
3. Manufacturer, make, model, and serial number.
4. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
5. Equipment manufacturers' proprietary instrumentation and tools. For each instrument or tool, identify the following:

   a. Instrument or tool identification number.
   b. Equipment schedule designation of equipment for which the instrument or tool is required.
   c. Manufacturer, make, model, and serial number.
   d. Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.

1.4 QUALITY ASSURANCE

A. BAS Testing Technician Qualifications: Technicians performing BAS Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations are to have the following minimum qualifications:

1. Journey level or equivalent skill level with knowledge of BAS, HVAC, electrical concepts, and building operations.

2. Minimum five years' experience installing, servicing, testing, operating systems manufactured by approved manufacturers.
3. International Society of Automation (ISA)-Certified Control Systems Technician (CCST) Level I.

B. HVAC Testing Technician Qualifications: Technicians to perform HVAC Construction Checklist, verification tests, functional performance tests, Cx test demonstrations, shall have the following minimum qualifications:

1. Journey level or equivalent skill level; vocational school four-year-program graduate or an Associate's degree in mechanical systems, air conditioning, or similar field. Degree may be offset by five years' experience in servicing mechanical systems in the HVAC industry. Generally, required knowledge includes HVAC systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of HVAC equipment, assemblies, and systems.
2. Minimum five years' experience that is to include installing, servicing, testing, operating systems of the type installed on this project, and manufactured by the approved manufacturers.

C. Testing Equipment and Instrumentation Quality and Calibration:

1. Capable of testing and measuring performance within the specified acceptance criteria.
2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
3. Be maintained in good repair and operating condition throughout duration of use on Project.
4. Be recalibrated/repaired if dropped or damaged in any way since last calibrated.

D. Proprietary Test Instrumentation and Tools:

1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, shall comply with the following:

   a. Be calibrated by manufacturer with current calibration tags permanently affixed.
   b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.

2. HVAC proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 Cx PROCESS:

A. Perform Cx process in accordance with Section 019113 "General Commissioning Requirements" for HVAC, BAS and in accordance with the following:

1. ASHRAE Standard 202 – Commissioning Process for Buildings and Systems.
2. Building Commissioning Association – Building Commissioning Handbook, 3rd Edition
3. AABC Commissioning Group – ACG Building Systems Commissioning Guideline.

3.2 CONSTRUCTION CHECKLISTS AND PERFORMANCE VERIFICATION CHECKLISTS

A. Detailed checklists are to be prepared by the CxA under Section 019113 "General Commissioning Requirements" for each commissioned system, assembly, subsystem, equipment, and component, as detailed in ASHRAE 202. Perform the following:

1. The CxA is to generate HVAC and BAS preliminary construction checklists, and list of performance tests, to be submitted to installing contractors; who are to review and provide written comments on checklist items where appropriate.
2. The preliminary Construction Checklist with review comments are to be returned to the CxA within 10 days of receipt.
3. The performance tests checklists are to be returned to the CxA within 20 days of receipt.
4. When review comments have been resolved, the CxA will provide final checklists marked "Approved for Use, and date."
5. Use only checklists marked "Approved for Use, with date" when performing tests. Mark construction checklists in the appropriate place as indicated project events are completed, and provide pertinent details and other information.

3.3 Cx TESTING PREPARATION

A. The CxA is to certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating in accordance with the Contract Documents and approved submittals.

B. The CxA is to Certify that HVAC instrumentation and control systems have been completed and calibrated, point-to-point checkout has been successfully completed, and systems are operating in accordance with their design sequence of operation, Contract Documents, and approved submittals; and certify that all sensors are operating within specified accuracy and all systems are set to, and maintaining, set points as required by the design documents.

C. The CxA is to certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.

D. The CxA is to set systems, subsystems, and equipment into operating mode to be tested in accordance with approved test procedures (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, alarm conditions).

3.4 Cx TEST CONDITIONS

A. The CxA is to perform tests using design conditions, whenever possible.

1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.

B. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to construction manager and general contractor. After deficiencies are resolved, reschedule tests.

C. If seasonal testing is specified, complete appropriate initial performance tests and documentation, and schedule seasonal tests.

3.5 TESTS COMMON TO HVAC SYSTEMS TO BE PERFORMED BY THE CXA

A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.

B. Test systems, assemblies, subsystems, equipment, and components for operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response in accordance with acceptance criteria.

C. Coordinate schedule with the general contractor, construction manager, and affected trades.

D. Perform tests following the Construction Checklist requirements, including material verification, installation checks, and performance test requirements; including those specified in Division 23 sections specific to the installed HVAC and BAS systems and equipment.

E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:

1. Cx Construction Checklist verification tests.
2. Cx Performance Checklist tests and demonstrations.

3.6 TAB VERIFICATION BY CXA

A. Prerequisites: Certify completion of "Examination" article requirements and correction of deficiencies, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

B. Certify the completion of "Preparation" article requirements for preparation of a TAB plan that includes strategies and step-by-step procedures, and system-readiness checks and reports, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

C. Conditions of the Test:

1. CxA shall perform testing and demonstration based upon sampling rate: As specified in “Verification of TAB Report” article in Section 230593 "Testing, Adjusting, and Balancing for HVAC"; “inspection”
   a. Air systems operating in design heating, design cooling, economizer, reheat modes
   b. Hydronic systems operating in design heating, cooling, minimum flow and variable flow modes.
   c. For measurements at air-handling units with economizer controls; systems operating in economizer mode with 100 percent outside air.

D. Acceptance Criteria:

1. Under all conditions, rechecked measurements comply with "Verification of TAB Report" article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
2. Additionally, no rechecked measurement shall differ from measurements documented in the final report by more than the tolerances allowed.
3. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

3.7 PRIMARY HEATING SYSTEM Cx TESTS BY CXA

A. Prerequisites: verification of the following:

1. Startup of boiler, boiler integral controls functionality, primary pumps, flow

switches, interlocks alarms.
2. TAB of heating-water flow and pressure.
3. Input Device: Heating-water supply and return temperature
4. Output Device: Control valves, balancing valves, flow switches, staging and cascading.
5. Display of all operating inputs, outputs, performance criteria, modes, status, trends and alarms at the BAS operator's workstation:
6. Heating-water system; control of heating-water supply temperatures.
   a. Minimum heating-water flow.
   b. Midrange Heating-Water Flow: 50 to 60 percent of maximum.
   c. Maximum heating-water flow.
   d. Acceptance Criteria: Under all conditions, heating-water supply temperature is within plus or minus 2.0 deg F of set point.

B. Functional: perform tests to verify operation:

1. Demonstrate and confirm sequence of operation defined in specification section 230993 for subsystem, associated equipment, controllers, control devices; including but not limited to the following….
   a. Hot water temperature setpoints
   b. Hot water temperature reset
   c. Cascading, lead-lag, standby
   d. Unoccupied setbacks and morning warm-ups
   e. Hot water temperature trends and alarms

3.8 HEATING SYSTEM DISTRIBUTION CX TESTS BY CXA

A. Prerequisites: verification of the following:

1. Startup of building pumps, flow meters, VFD functionality, interlocks alarms.
2. TAB of building heating-water flow and pressure.
3. Input Device: building heating-water supply and return temperature
4. Output Device: Control valves, balancing valves, flow switches, pressure differential and minimum flow controls.
5. Display of all operating inputs, outputs, performance criteria, modes, status, trends and alarms at the BAS operator's workstation:
6. Building Heating-water system; control of heating-water flows.
   a. Minimum building heating-water flow.
   b. Midrange building Heating-Water Flow: 50 to 60 percent of maximum.
   c. Maximum building heating-water flow
   d. Acceptance Criteria: Under all conditions, minimums are maintained, VFDs response to system changes (valves) holding pressure differential within required range of accuracy.

B. Functional: perform tests to verify operation:

1. Demonstrate and confirm sequence of operation defined in specification section 230993 for pumping/distribution subsystem, associated equipment, controllers, control devices; including but not limited to the following…..
    a. Building Hot water supply and return temperatures
    b. Pressure differential
    c. Minimum flows
    d. Design flows
    e. Pump speed control
    f. Response to system changes (control valves)
    g. Unoccupied setbacks, morning warm-ups
    h. Reheat for dehumidification
    i. Hot water temperature trends and alarms

3.9 CHILLER SYSTEM Cx TESTS BY CXA

A. Prerequisites: Installation verification of the following:
    1. Chiller operational, started, flow switch confirmed.
    2. Evaporator minimum flow established
    3. TAB of flows and pressures completed and correct
    4. Supply and return water temperature devices
    5. Integral control functionality tested and confirmed
    6. Display of mode, load, temperatures, setpoints, flow switch, performance, trends and alarms at BAS operator workstation.
    7. Control of chilled water system: temperatures:
        a. Chilled water temperatures, supply and return.
        b. Chilled water temperature resets.
        c. Chilled water set-point.
        d. Minimum flow and flow switch confirm.

B. Functional: perform tests to verify operation:
    1. Demonstrate and confirm sequence of operation defined in specification section 230993 for chilled water chiller subsystem, associated equipment, controllers, control devices; including but not limited to the following…..
        a. Building chilled water supply and return temperatures
        b. Pressure differential
        c. Minimum flows
        d. Unoccupied mode and morning cool-down
        e. Chilled water trends and alarms.

3.10 CHILLED WATER SYSTEM DISTRIBUTION CX TESTS BY CXA

A. Prerequisites: verification of the following:
    1. Startup of building pumps, flow meters, VFD functionality, interlocks alarms.

2. TAB of building chilled-water flow and pressure.
3. Input Device: building chilled-water supply and return temperature
4. Output Device: Control valves, balancing valves, flow switches, pressure differential and minimum flow controls.
5. Display of all operating inputs, outputs, performance criteria, modes, status, trends and alarms at the BAS operator's workstation:
6. Building chilled-water system; control of chilled water flows.
   a. Minimum building chilled-water flow for chiller operation.
   b. Midrange building chilled-Water Flow: 60-70 percent of maximum.
   c. Maximum building chilled-water flow
   d. Acceptance Criteria: Under all conditions, minimums are maintained, VFDs response to system changes (valves) holding pressure differential within required range of accuracy.

B. Functional: perform tests to verify operation:

1. Demonstrate and confirm sequence of operation defined in specification section 230993 for chilled water pumping/distribution subsystem, associated equipment, controllers, control devices; including but not limited to the following…..
   a. Building chilled water supply and return temperatures
   b. Pressure differential
   c. Minimum flows
   d. Design flows
   e. Pump speed control
   f. Response to system changes (control valves)
   g. Unoccupied setbacks, morning cool-downs
   h. Dehumidification
   i. Chilled water temperature trends and alarms

3.11 TERMINAL UNIT EQUIPMENT Cx TESTS BY CXA

A. Prerequisites: Installation verification of the following:

1. Input Device: space temperature and relative humidity sensors.
2. Occupancy Output Device: DDC system analog outputs.
3. Primary damper actuators, fan contacts, control-valve operators.
4. Display the following at the operator's workstation:
   a. Room/area served.
   b. Room temperature indication.
   c. Room temperature set point.
   d. Room temperature set point, occupied.
   e. Room temperature set point, unoccupied.
   f. Air-damper position as percentage open.
   g. Control-valve position as percentage open.
   h. Primary air flow (cfm)
   i. Fan operation

j. All trends, alarms

B. Functional: perform tests to verify operation:

1. Demonstrate and confirm sequence of operation defined in specification section 230993 for fan-powered variable volume hot water reheat terminals, variable air volume hot water reheat terminals subsystems, associated equipment, controllers, control devices; including but not limited to the following…..

a. Primary air flow modulation for space temperature setpoint
b. Primary air flow minimums for heating and ventilation
c. Primary air flow ring accuracy, response, air flow readings
d. Hot water reheat coil modulation for space temperature
e. Hot water reheat coil modulation for reheat, dehumidification
f. Setbacks for unoccupied, morning warm-up, morning cool-down
g. Maintain space temperature and relative humidity

3.12 AIR-HANDLING SYSTEM Cx TESTS BY CXA

A. Supply, Exhaust/Return Fan(s) Variable-Volume Control:

1. Prerequisites: Installation verification of the following:

a. Volume-Control Input Device: Static-pressure transmitter, Differential-pressure switch, sensing supply-duct static pressure referenced to conditioned-space static pressure.
b. Volume-Control Output Device: DDC system analog output to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
c. High-Pressure Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
d. High-and -Low static pressure safety devices.
e. Integral unit control functionality confirmed
f. Display the following at the operator's workstation:

1) fan-discharge static-pressure indication.
2) fan-discharge static-pressure set point.
3) fan airflow rate.
4) fan speed.

2. Conditions of the Test:

a. Minimum supply-air flow.
b. Midrange Supply-Air Flow: 60 to 70 percent of maximum.
c. Maximum supply-air flow.
d. Excess supply-air discharge static pressure.

3. Acceptance Criteria:

a. At all supply-air flow rates, and during changes in supply-air flow, discharge air static pressure is at set point plus or minus 2 percent.
b. Fan stops and an alarm is initiated at the operator's workstation when

supply-air discharge static pressure is at the excess static pressure

B. Air-Handler Mixed-Air Control:

1. Prerequisites: Installation verification of the following:

a. Minimum Position Input Device: DDC system time schedule
b. Output Device: DDC system analog output to modulating damper actuator(s).
c. Supply air temperature reset Input Device: DDC system software.
d. Supply/Mixed-Air Temperature Input Device: Duct-mounted Electronic temperature sensor.
e. Airflow measuring stations, accuracy within requirements compared to actual flow, response by mixing dampers
f. Cooling Reset Input Device: Outdoor- and return-air, duct-mounted electronic temperature sensors.
g. Display the following at the operator's workstation:

1) Mixed-air-temperature-humidity indication.
2) Mixed-air-temperature-humidity set point.
3) Outdoor temperature/humidity
4) Outdoor air ventilation flow rate, actual, setpoint
5) Mixed-air dampers positions.

2. Conditions of the Test:

a. Occupied Time Control: Start in unoccupied schedule. Advance to occupied schedule time.
b. Minimum Damper Position Control: Command system to mode in which minimum damper position is required.
c. Heating Reset Control: Create a call for heating.
d. Supply-Mixed-Air Temperature Control: Override air temperature set point to a value 2.0 deg F outside air temperature.
e. Cooling Reset Control: Override outdoor-air temperature to a value that exceeds return-air temperature/enthalpy to a value that exceeds return-air enthalpy.
f. Unoccupied Time Control: Advance to unoccupied schedule time.
g. Display the following at the operator’s workstation.

1) Minimum position input device.
2) Heating reset input device.
3) Supply/Mixed-air temperature input device.
4) Cooling reset input device.

C. Chilled water, Hot Water Coils Control:

1. Prerequisites: Installation verification of the following:

a. Control valves modulating in response to system temperature setpoint
b. Supply air temperature setpoint duct mounted sensor, analog input to valve

and DDC system.

c. Reset of supply air temperatures through DDC system programming.
d. High/low temperature limits, shut-downs, alarms.
e. Display the following at the operator's workstation:

1) Mode of operation.
2) Supply air temperature set point
3) Actual supply air temperature
4) Valve operation, valve position (% heating or cooling).
5) Temperature resets
6) Morning Warm-up , cool-down
7) Trends and alarms

D. Functional: perform tests to verify operation:

1. Demonstrate and confirm sequence of operation defined in specification section 230993 for air handling units, variable air volume fans, mixing dampers, heating and cooling coils, associated components, controllers, control devices; including but not limited to the following….

a. Air flow modulation for building system supply air
b. Response to static pressure setpoints
c. Reset of static pressure duct setpoint
d. Maintaining supply air temperatures for heating and cooling
e. Resetting of supply air temperature setpoints
f. Modulating mixed damper positioning to maintain minimum ventilation outdoor air during occupied schedules
g. Modulation of mixing dampers for economizer cooling through comparative enthalpy.
h. Setbacks for unoccupied, morning warm-up, morning cool-down
i. Shutdown, Start, alarm responses.

3.13 PACKAGED UNITS Cx TESTS BY CXA

A. Supply, Exhaust/Return Fan(s) Variable-Volume Control:

1. Prerequisites: Installation verification of the following:

a. Volume-Control Input Device: Static-pressure transmitter, Differential-pressure switch, sensing supply-duct static pressure referenced to conditioned-space static pressure.
b. Volume-Control Output Device: DDC system analog output to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
c. High-Pressure Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
d. High-and -Low static pressure safety devices.
e. Integral unit control functionality confirmed
f. Display the following at the operator's workstation:

1) fan-discharge static-pressure indication.
2) fan-discharge static-pressure set point.
3) fan airflow rate.
4) fan speed.

2. Conditions of the Test:

a. Minimum supply-air flow.
b. Midrange Supply-Air Flow: 60 to 70 percent of maximum.
c. Maximum supply-air flow.
d. Excess supply-air discharge static pressure.
e. Acceptance Criteria:

1) At all supply-air flow rates, and during changes in supply-air flow, discharge air static pressure is at set point plus or minus 2 percent.
2) Fan stops and an alarm is initiated at the operator's workstation when supply-air discharge static pressure is at the excess static pressure

B. Unit Mixed-Air Control:

1. Prerequisites: Installation verification of the following:

a. Minimum Position Input Device: DDC system time schedule
b. Output Device: DDC system analog output to modulating damper actuator(s).
c. Supply air temperature reset Input Device: DDC system software.
d. Supply/Mixed-Air Temperature Input Device: Duct-mounted Electronic temperature sensor.
e. Airflow measuring stations, accuracy within requirements compared to actual flow, response by mixing dampers
f. Cooling Reset Input Device: Outdoor- and return-air, duct-mounted electronic temperature sensors.
g. Display the following at the operator's workstation:

1) Mixed-air-temperature-humidity indication.
2) Mixed-air-temperature-humidity set point.
3) Outdoor temperature/humidity
4) Outdoor air ventilation flow rate, actual, setpoint
5) Mixed-air dampers positions.

2. Conditions of the Test:

a. Occupied Time Control: Start in unoccupied schedule. Advance to occupied schedule time.
b. Minimum Damper Position Control: Command system to mode in which minimum damper position is required.
c. Heating Reset Control: Create a call for heating.
d. Supply-Mixed-Air Temperature Control: Override air temperature set point to a value 2.0 deg F outside air temperature.

e. Cooling Reset Control: Override outdoor-air temperature to a value that exceeds return-air temperature/enthalpy to a value that exceeds return-air enthalpy.
f. Unoccupied Time Control: Advance to unoccupied schedule time.
g. Display the following at the operator’s workstation.

1) Minimum position input device.
2) Heating reset input device.
3) Supply/Mixed-air temperature input device.
4) Cooling reset input device.

C. Cooling and Heating Control:

1. Prerequisites: Installation verification of the following:

a. System integral controls have complete functionality
b. Supply air temperature cooling setpoint duct mounted sensor, analog input to refrigeration, staging of cooling, compressors, TXVs.
c. Supply air heating temperature through modulation of furnace gas valve, analog input maintains supply air temperature.
d. Reset of supply air temperatures through DDC system programming.
e. High/low temperature limits, shut-downs, alarms.
f. Display the following at the operator's workstation:

1) Mode of operation.
2) Supply air temperature set point
3) Actual supply air temperature
4) Cooling operation, compressor staging, status, percent cooling
5) Furnace operation, percent heating.
6) Temperature resets
7) Morning Warm-up and morning cool-down
8) Trends and alarms

D. Functional: perform tests to verify operation:

1. Demonstrate and confirm sequence of operation defined in specification section 230993 for packaged units, variable air volume fans, mixing dampers, gas-fired heating and refrigerant cooling, associated components, controllers, control devices; including but not limited to the following….

a. Air flow modulation for building system supply air
b. Response to static pressure setpoints
c. Reset of static pressure duct setpoint
d. Maintaining supply air temperatures for heating and cooling
e. Resetting of supply air temperature setpoints
f. Modulating mixed damper positioning to maintain minimum ventilation outdoor air during occupied schedules
g. Modulation of mixing dampers for economizer cooling through comparative enthalpy.

h. Setbacks for unoccupied, morning warm-up, morning cool-down
i. Shutdown, Start, alarm responses.

3.14 CABINET AND UNIT HEATERS CX TESTS BY CXA

A. Functional performance tests, verifying operation:

1. Demonstrate and confirm sequence of operation defined in specification section 230993 for hydronic unit heating, associated components, controllers, control devices; including but not limited to the following….

a. Start, stop, fan operation
b. Modulating heating hot water control valve operation
c. Response to heating analog signal for space temperature
d. Maintaining room temperatures
e. Setback, morning warm-up
f. Limits, alarms, trending

3.15 SYSTEMS MONITORING, CX TESTS BY CXA

A. Functional performance tests, verifying monitoring and alarming:

1. Demonstrate and confirm sequence of operation defined in specification section 230993 for subsystems, associated components, controllers, control devices; including but not limited to the following….

a. Server room cooling, operation of cooling units, space temperature
b. Elevator machine room heating and cooling, operating mode, space temperature
c. Glycol feeder operation, limits, alarms
d. Water room temperature
e. Limits and alarms

END OF SECTION 230800

SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Direct digital control (DDC) system equipment and components for updating the existing system for the purpose of monitoring and controlling of new and existing HVAC, exclusive of instrumentation and control devices.

B. Related Requirements:

1. Section 230923.11 "Control Valves”.
2. Section 230923.12 "Control Dampers”.
3. Section 230923.14 "Flow Instruments”
4. Section 230923.19 "Moisture Instruments”
5. Section 230923.23 “Pressure Instruments”
6. Section 230923.27 “Temperature Instruments”
7. Section 230993.11 "Sequence of Operations for HVAC DDC"

1.2 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BAS: Building Automation System, a software-based system for monitoring and controlling building application such as heating, ventilation and air-conditioning control, energy management, lighting control.

D. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE Standard 135-2020. A communications protocol allowing devices to communicate data and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
4. BACnet Testing Laboratories (BTL): Organization responsible for testing

products for compliance with ASHRAE Standard 135-2020, operated under direction of BACnet International.1

E. Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

F. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: network controllers, programmable application controllers, and application-specific controllers.

G. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

H. COV: Changes of value.

I. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

J. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems to be capable of operating in a standalone mode using the last best available data.

K. E/P: Voltage to pneumatic.

L. Front-end (or “Head-end”) is the BAS software resident in the OWS which manages, controls, commands and monitors all BAS system functions and interfaces, including interfaces to the internet, and is also responsible for generating the graphical user interface whereby Owners monitor, input, and operate the systems served by the BAS.

M. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

N. HLC: Heavy load conditions.

O. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI) and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

P. LAN: Local area network.

Q. LNS: LonWorks Network Services.

R. LON Specific Definitions:

1. FTT-10: Echelon Transmitter-Free Topology Transceiver.
2. LonMark International: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.
3. LonTalk: An open standard protocol developed by Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.
4. LonWorks: Network technology developed by Echelon.
5. Node: Device that communicates using CTA-709.1-D protocol and that is connected to a CTA-709.1-D network.
6. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number, and Node number. "Node number" portion of an address is a number assigned to device during installation, is unique within a subnet, and is not a factory-set unique Node ID.
7. Node ID: A unique 48-bit identifier assigned at factory to each CTA-709.1-D device. Sometimes called a "Neuron ID."
8. Program ID: An identifier (number) stored in a device (usually, EEPROM) that identifies node manufacturer, functionality of device (application and sequence), transceiver used, and intended device usage.
9. Standard Configuration Property Type (SCPT): Pronounced "skip-it." A standard format type maintained by LonMark for configuration properties.
10. Standard Network Variable Type (SNVT): Pronounced "snivet." A standard format type maintained by LonMark used to define data information transmitted and received by individual nodes. "SNVT" is used in two ways. It is an acronym for "Standard Network Variable Type" and is often used to indicate a network variable itself (i.e., it can mean "a network variable of a standard network variable type").
11. Subnet: Consists of a logical grouping of up to 127 nodes, where logical grouping is defined by node addressing. Each subnet is assigned a number, which is unique within a Domain. See "Node Address."
12. TP/FT-10: Free Topology Twisted Pair network defined by CTA-709.3 and is most common media type for a CTA-709.1-D control network.
13. TP/XF-1250: High-speed, 1.25 Mbps, twisted-pair, doubly terminated bus network defined by "LonMark Interoperability Guidelines" and typically used only to connect multiple TP/FT-10 networks.
14. User-Defined Configuration Property Type (UCPT): Pronounced "u-keep-it." A Configuration Property format type that is defined by device manufacturer.
15. User-Defined Network Variable Type (UNVT): Network variable format defined by device manufacturer. UNVTs create non-standard communications that other vendors' devices may not correctly interpret and may negatively impact system operation. UNVTs are not allowed.

S. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

T. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.

U. Modbus TCP/IP: An open protocol for exchange of process data.

V. MS/TP: Master-slave/token-passing, ISO/IEC/IEEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

W. MTBF: Mean time between failures.

X. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

Y. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

Z. OWS: Operator Work Station, serving as the central data and command terminal for the BAS, a high level-processing desktop personal computer which acts as the main point of user interface.

AA. Peer to Peer: Networking architecture that treats all network stations as equal partners.

BB. POT: Portable operator's terminal.

CC. RAM: Random access memory.

DD. RF: Radio frequency.

EE. Router: Device connecting two or more networks at network layer.

FF. Server: Computer used to maintain system configuration, historical and programming database.

GG. TCP/IP: Transport control protocol/Internet protocol.

HH. Thick client: BAS system operator interface device with front-end software installed on the client device.

II. Thin client: BAS system operator interface device where communication with the front-end software is through the internet or other network.

JJ. USB: Universal Serial Bus.

KK. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

LL. VAV: Variable air volume.

MM. WLED: White light emitting diode.

NN. ASHRAE 13: Titled “Specifying Building Automation Systems”, ASHRAE Guideline 13 – 2015, developed and published by ASHRAE to provide designers of building automation systems with background information, recommendations for good practice, project considerations, and detailed discussion of options with respect to design of a building automation system.

OO. ASHRAE 35: Titled “BACnet – A Data Communication Protocol for Building Automation and Control Networks”, ASHRAE Guideline 135-2020, developed and published by ASHRAE for the purpose of the communication needs of the building automation and controls systems for application such as heating, ventilation and air-conditioning control, energy management, lighting control. The BACnet protocol provides mechanisms by which computerized equipment of arbitrary function may exchange information, regardless of the particular building service it performs; and the protocol may be used by mobile and cloud-hosted devices, head-end computers, general-purpose direct digital controllers, and application-specific and unitary controllers with equal effect.

PP. ASHRAE 36: Titled “High-Performance Sequence of Operations for HVAC Systems”, ASHRAE Guideline 36-2021, including appendix C, developed and published by ASHRAE for the purpose of providing uniform sequences of operation for heating, ventilating, and air conditioning system that are intended to maximize performance and energy efficiency, stability and allow for real-time fault detection and diagnostics. The guideline provides detailed sequences of operation for HVAC, and describes functional tests for confirmation of the proper implementation of sequences of operation.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site minimum 2 weeks before scheduled start of any field work.

1.4 ACTION SUBMITTALS

A. Submit following procedures outlined in Division 1. Minimum three complete sets of controls drawings.

1. Displaying control equipment and components for each of the various systems, identifying functions. Include all values, calibration values and setpoints, and set up parameters.. Include the proposed sequence of operation for systems.

2. Include all application software documentation for the actual programs, including job specific flowcharts for the DDC systems.

B. Provide in common software formats, editable and printable (eg AutoCAD, .pdf, .doc, .xls), all text searchable. Submit both the files and printed full sized.

C. Multiple Submissions:

1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

D. Product Data:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.

a. Workstations.
b. Gateways.
c. Routers.
d. Protocol analyzers.
e. DDC controllers.
f. Enclosures.
g. Electrical power devices.
h. Accessories.
i. Instruments.
j. Control dampers and actuators.
k. Control valves and actuators.
l. Application Specific Controllers
m. Sensors.

6. When manufacturer's product datasheets apply to a product series rather than a

specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature to clearly cross reference specification and drawings that submittal is to cover.

E. Software Submittal:

1. The new control system shall use the existing headend software on the existing OWS (server) for the building automation system communication
2. The new control system shall fully integrate into the existing systems to completely communicate to existing OWS, web-servers.
3. The system shall provide all communication between DDC panels, controllers, modules, I/O points, schedules, setpoints, alarms and trends as specified in these documents.
4. Cross-referenced listing of existing head-end software loaded on the existing server, software to be loaded to portable operator workstation, and DDC controllers, including any updates or additions to the existing head-end software.
5. Description and technical data of all software, both existing and new to be provided, and cross-referenced to products in which software will be installed.
6. Operating system software, both existing and necessary updates and additions to be provided, detailing operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
7. Include a flow diagram in the form of a complete control system “architecture” and an outline of each subroutine that indicates each program variable name and units of measure.
8. Listing and description of each engineering equation used with reference source.
9. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
10. Description of operator interface to alphanumeric and graphic programming.
11. Description of each network communication protocol.
12. Description of system database, including all data included in database, database capacity, and limitations to expand database.
13. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden, and system throughout.
14. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

F. Shop Drawings:

1. General Requirements:

a. Include cover drawing with Project name, location, Owner, Architect, Contractor, and issue date with each Shop Drawings submission.
b. Include a drawing index sheet listing each drawing number and title that

matches information in each title block.

   c. Drawings Size: 17 by 11, submitted in both electronic format and .pdf format.

2. Include plans, elevations, sections, and mounting details where applicable.
3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail means of vibration isolation and show attachments to rotating equipment.
5. Full Plan Drawings indicating the following:
   a. Backgrounds of space, walls, structural grid lines.
   b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
   c. Locations of workstation network port, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller.
   d. Network communication cable and raceway routing.
6. Schematic drawings for each controlled HVAC system indicating the following:
   a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
   b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
   c. A graphic showing location of control I/O in proper relationship to HVAC system.
   d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
   e. Unique identification of each I/O that to be consistently used between different drawings showing same point.
   f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.
   g. Narrative sequence of operation.
   h. Graphic sequence of operation, showing all inputs and output logical blocks.
7. Control panel drawings indicating the following:
   a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
   b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates, and allocated spare space.
8. DDC system network riser diagram indicating the following:
   a. Each device connected to network with unique identification for each.
   b. Interconnection of each different network in DDC system.

c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

9. DDC system electrical power riser diagram indicating the following:

a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
d. Power wiring type and size, race type, and size for each.

10. Monitoring and control signal diagrams indicating the following:

a. Control signal cable and wiring between controllers and I/O.
b. Point-to-point schematic wiring diagrams for each product.
c. Control signal tubing to sensors, switches, and transmitters.
d. Process signal tubing to sensors, switches, and transmitters.

11. Color graphics indicating the following:

a. Itemized list of color graphic displays to be provided.
b. For each display screen to be provided, a true color copy showing layout of pictures, graphics, and data displayed.
c. Intended operator access between related hierarchical display screens.

G. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing, and events that initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:

a. Loss of power.
b. Loss of network communication signal.
c. Loss of controller signals to inputs and outpoints.
d. Operator workstation failure.
e. Server failure.
f. Gateway failure.
g. Network failure.
h. Controller failure.
i. Instrument failure.

j. Control damper and valve actuator failure.

4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

H. Delegated Design Submittals: For DDC system products and installation indicated as being delegated.

1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
2. Schedule and design calculations for control dampers and actuators.

   a. Flow at Project design and minimum flow conditions.
   b. Face velocity at Project design and minimum airflow conditions.
   c. Pressure drop across damper at Project design and minimum airflow conditions.
   d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
   e. Maximum close-off pressure.
   f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
   g. Torque required at worst case condition for sizing actuator.
   h. Actuator selection indicating torque provided.
   i. Actuator signal to control damper (on, close, or modulate).
   j. Actuator position on loss of power.
   k. Actuator position on loss of control signal.

3. Schedule and design calculations for control valves and actuators.

   a. Flow at Project design and minimum flow conditions.
   b. Pressure-differential drop across valve at Project design flow condition.
   c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
   d. Design and minimum control valve coefficient with corresponding valve position.
   e. Maximum close-off pressure.
   f. Leakage flow at maximum system pressure differential.
   g. Torque required at worst case condition for sizing actuator.
   h. Actuator selection indicating torque provided.
   i. Actuator signal to control damper (on, close or modulate).
   j. Actuator position on loss of power.
   k. Actuator position on loss of control signal.

4. Schedule and design calculations for selecting flow instruments.

   a. Instrument flow range.
   b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter, and output signal for remote control.

c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter, and output signal for remote control.
d. Pressure-differential loss across instrument at Project design flow conditions.
e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

I. Sustainable Design Submittals:

1. Product Data: For indicated products, indicating compliance with requirements for ENERGY STAR product labeling.
2. ENERGY STAR: Product Data for indicated products, showing compliance with requirements for ENERGY STAR product labeling.
3. Product Data: For adhesives and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives and sealants, indicating compliance with requirements for low-emitting materials.

1.5 INFORMATIONAL SUBMITTALS

A. Provide in common software formats, editable and printable (eg AutoCAD, .pdf, .doc, .xls), all text searchable. Submit both the files and printed full sized.

B. Coordination Drawings:

1. Plan drawings and corresponding product installation details, drawn to scale, on which the items described and referenced herein are shown and coordinated with each other, using input from installers of the items involved.
2. Reflected ceiling plans and other architectural details, drawn to scale, on which items are shown and coordinated with each other, using input from installers of the items involved.
3. Provide the information described above to the other disciplines for incorporating into project mechanical systems coordination drawings described in section 230500.

C. Qualification Statements:

1. Systems Provider's Qualification Data:

a. Resume of project manager assigned to Project.
b. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity, and building's primary function.
c. Description of past project DDC system, noting similarities to Project scope and complexity indicated.

2. Manufacturer's qualification data.
3. Testing agency's qualification data.

D. Product Certificates:

1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.
2. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with LonWorks, where applicable.

E. Test and Evaluation Reports:

1. Product Test Reports: For each product, for tests performed by the manufacturer.
2. Preconstruction Test Reports: For each separate test performed.

F. Source Quality-Control Submittals:

1. Source quality-control reports.

G. Field Quality-Control Submittals:

1. Field quality-control reports.

H. Warranty of the installation, and manufacturers' warranties.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system.

1. In addition to items specified in Section 230500, and Division 1 specifications requiring operation and maintenance data; include the following:
    a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic and PDF formats.
    b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
    c. As-built versions of submittal Product Data.
    d. Names, addresses, email addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
    e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
    f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
    g. Engineering, installation, and maintenance manuals that explain how to do the following:
        1) Design and install new points, panels, and other hardware.
        2) Perform preventive maintenance and calibration.
        3) Debug hardware problems.
        4) Repair or replace hardware.

h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and databases on electronic media.
j. List of recommended spare parts with part numbers and suppliers.
k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
m. Licenses, guarantees, and warranty documents.
n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
o. Owner training materials.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Material: Furnish extra materials and parts to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Include product manufacturers' recommended parts lists for proper product operation following warranty period. Parts list to be indicated for each year.

C. Furnish quantity indicated of matching product(s) in Project inventory for each unique size and type of following:

1. Reheat Air Terminal control valves with actuators, one each of the three most common Cv ratings: Three.
2. Current-Sensing Relay: One.
3. Space Temperature Sensor: Four
4. Space RH sensor: Two

1.8 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
3. DDC systems and products that have been successfully tested and in use on at least three past projects.
4. Having complete published catalog literature, installation, operation, and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:

a. Product research and development.
b. Product and application engineering.
c. Product manufacturing, testing, and quality control.
d. Technical support for DDC system installation training, commissioning, and troubleshooting of installations.
e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and/or trained/licensed by, DDC system manufacturer.
2. In-place support facility located within 80 miles of Project having technical staff, parts inventory, test and diagnostic tools necessary for supporting the project.
3. Demonstrate past experience with installation of DDC system products being installed for period within three consecutive years before time of bid.
4. Demonstrate past experience on five projects of similar complexity, scope, and value.
5. Demonstrate past experience of each person assigned to Project.
6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
7. Service and maintenance staff assigned to support Project during warranty period.
8. Product parts inventory to support ongoing DDC system operation for a period of not less than five years after Substantial Completion.
9. DDC system manufacturer's backing to take over execution of the Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

1.9 WARRANTY

A. the temperature controls contractor will guarantee all components, system software and devices supplied the project against defects in material and workmanship for one year from the date of acceptance by the project manager.

1. The date of acceptance is the date upon which all software, hardware, controllers and sensors are completely installed and functioning, fully tested and demonstrated to the owner. Minor items not impacting operation, where a resolution, mutually agreed to by temperature controls contractor and construction manager, is in progress, would not delay establishing the date of acceptance.

B. Special Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Adjust, repair, or replace failures at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve

deficiencies, at no additional cost to Owner.

a. Install updates only after receiving Owner's written authorization.

3. Perform warranty service during normal business hours and commence within 24 hours of Owner's warranty service request.
4. Warranty Period: Two years from date of Acceptance of the completed and tested system in full operation.

a. For Gateway: Three year parts and labor warranty for each.

PART 2 - PRODUCTS

2.1 DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. Automated Logic Corporation
2. Delta Controls Inc
3. Honeywell International Inc.
4. KMC Controls, Inc.
5. Schneider Electric USA, Inc.

2.2 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system consisting of high-speed, peer-to-peer network of distributed DDC controllers and other network devices, operator interfaces, and software.

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.

2.3 WEB ACCESS

A. DDC system to be web compatible.

1. Web-Compatible Access to DDC System:

a. Existing Operator Workstation and new portable workstation to perform overall system supervision and configuration, graphical user interface,

management report generation, trending, and alarm annunciation.
- b. DDC system to support web browser access to building data. Operator using a standard web browser is able to access control graphics and change adjustable set points.
- c. Alpha-numeric plus special character password-protected web access.

2.4 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. DDC system for monitoring and controlling of HVAC systems.

B. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

C. Delegated Design, Qualified Professional Engineer: Engage a qualified professional engineer, as defined in Division 1, to design DDC system to satisfy requirements indicated.

D. Delegated Design, Qualified Professional: Engage a qualified professional to design DDC system to satisfy requirements indicated.

1. System Performance Objectives:
   - a. DDC system manages HVAC systems.
   - b. DDC system operates HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
   - c. DDC system responds to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
   - d. DDC system operates while unattended by an operator and through operator interaction.
   - e. DDC system records trends and transactions of events and produces report information such as performance, energy, occupancies, and equipment operation.

E. Surface-Burning Characteristics: Products installed complying with ASTM E84; testing 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: 50 or less.

F. DDC System Speed:

1. Response Time of Connected I/O:
   - a. Update AI point values connected to DDC system at least every five seconds for use by DDC controllers. Points used globally to also comply

with this requirement.

b. Update BI point values connected to DDC system at least every five seconds for use by DDC controllers. Points used globally to also comply with this requirement.

c. AO points connected to DDC system to begin to respond to controller output commands within two second(s). Global commands to also comply with this requirement.

d. BO point values connected to DDC system to respond to controller output commands within two seconds. Global commands to also comply with this requirement.

2. Display of Connected I/O:

a. Update and display analog point COV connected to DDC system at least every 10 seconds for use by operator.

b. Update and display binary point COV connected to DDC system at least every 10 seconds for use by operator.

c. Update and display alarms of analog and digital points connected to DDC system within 30 seconds of activation or change of state.

d. Update graphic display refresh within eight seconds.

e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations to not exceed graphic refresh rate indicated.

G. Network Bandwidth: Design each network of DDC system to include spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions. Minimum spare bandwidth as follows:

1. Level 1 Networks: 30.
2. Level 2 Networks: 30.
3. Level 3 Networks: 20.

H. DDC System Data Storage:

1. Include capability to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends, and other information indicated.

2. Local Storage:

a. Provide data storage capacity indicated; using IT industry standard database platforms and capable of functions described in "DDC Data Access" Paragraph.

3. Cloud Storage:

a. Provide application-based and web browser interfaces to configure, upload, download, and manage data and to service plan with storage adequate to store all data for term indicated. Cloud storage to use IT industry standard database platforms and is capable of functions described in "DDC Data Access" Paragraph.

I. DDC Data Access:

1. When logged into the system, operator shall be able to also interact with any DDC controllers connected to DDC system as required for functional operation of DDC system, including those provided as part of existing or new major HVAC equipment by those manufacturers.
2. Use for application configuration; for archiving, reporting, and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

J. Future Expandability:

1. provide minimum 10% spare capacity for future point connection at each DDC control processor, of the type of spares in same proportion as the I/O functions implemented. The less than two spares of each implemented I/O type shall be provided.
2. Provide internal memory sufficient for the specified control sequences to have at least 25% of the memory needed available for future use.
3. Provide processors, communication controllers and power supplies complete and sufficient such that the implementation of additional points only requires the addition of the appropriate point I/O termination module, wiring.
4. DDC system size shall be expandable to an ultimate capacity of at least 1.5 times total I/O points indicated.
5. Design and install system networks to achieve ultimate capacity with only addition of DDC controllers, I/O, and associated wiring and cable. Design and install initial network infrastructure to support ultimate capacity without having to remove and replace portions of network installation.
6. Operator interfaces installed initially do not require hardware and software additions and revisions for system when operating at ultimate capacity.

K. Input Point Values Displayed Accuracy: Meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

1. Energy:
   a. Thermal: Within 5 percent of reading.
   b. Electric Power: Within 1 percent of reading.
   c. Requirements indicated on Drawings for meters not supplied by utility.
2. Flow:
   a. Air: Within 5 percent of design flow rate.
   b. Air Terminal Units: Within 5 percent of design flow rate.
   c. Water: Within 5 percent of design flow rate.

3. Gas:
    a. Carbon Dioxide: Within 50 ppm.
    b. Carbon Monoxide: Within 5 percent of reading.
    c. VOCs: Within 5 percent of reading.
4. Moisture (Relative Humidity):
    a. Air: Within 5 percent RH.
    b. Space: Within 5 percent RH.
    c. Outdoor: Within 5 percent RH.
5. Level: Within 5 percent of reading.
6. Pressure:
    a. Air, Ducts and Equipment: 1 percent of instrument range.
    b. Space: Within 1 percent of instrument range.
    c. Water: Within 1 percent of instrument range.
7. Speed: Within 5 percent of reading.
8. Temperature, Dew Point:
    a. Air: Within 1 deg F.
    b. Space: Within 1 deg F.
    c. Outdoor: Within 2 deg F.
9. Temperature, Dry Bulb:
    a. Air: Within 0.5 deg F.
    b. Space: Within 0.5 deg F.
    c. Outdoor: Within 2 deg F.
    d. Chilled Water: Within 1 deg F.
    e. Heating Hot Water: Within 1 deg F.
    f. Temperature Difference: Within 0.25 deg F.
    g. Other Temperatures Not Indicated: Within 0.5 deg F.
10. Temperature, Wet Bulb:
    a. Air: Within 0.5 deg F.
    b. Space: Within 0.5 deg F.
    c. Outdoor: Within 2 deg Feg F.
11. Vibration: Within 10 percent of reading.

L. Precision of I/O Reported Values: Values reported in database and displayed to have following precision:

1. Current:
    a. Milliamperes: Nearest 1/100th of a milliampere.
    b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.
2. Energy:

a. Electric Power:

1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.

b. Thermal, Rate:

1) Heating: For British thermal units per hour, nearest British thermal unit per hour up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For MBh, round to nearest MBh up to 1000 MBh; nearest 10 MBh between 1000 and 10,000 MBh; nearest 100 MBh above 10,000 MBh.
2) Cooling: For tons, nearest ton up to 100 tons.

c. Thermal, Usage:

1) Heating: For British thermal unit, nearest British thermal unit up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For MBtu, round to nearest MBtu up to 1000 MBtu; nearest 10 MBtu between 1000 and 10,000 MBtu; nearest 100 MBtu above 10,000 MBtu.
2) Cooling: For ton-hours, nearest ton-hours up to 100 ton-hours.

3. Flow:

a. Air: Nearest 1/10th of a cubic feet per minute through 100 cfm; nearest cubic feet per minute between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm.
b. Water: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm.

4. Gas:

a. Carbon Dioxide (ppm): Nearest ppm.
b. Carbon Monoxide (ppm): Nearest ppm.
c. Volatile Organic Compounds (ppm): Nearest ppm

5. Moisture (Relative Humidity): Relative Humidity (Percentage): Nearest 1 percent.
6. Level: Nearest 1/100th of an inch through 10 inches; nearest 1/10 of an inch between 10 and 100 inches; nearest inch above 100 inches.
7. Speed:

a. Rotation (rpm): Nearest 1 rpm.
b. Velocity: Nearest 1/10th of feet per minute through 100 fpm; nearest feet per minute between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm.

8. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
9. Pressure:

a. Air, Ducts and Equipment: Nearest 1/10th of an inch water closet.
b. Space: Nearest 1/100th of an inch water closet.
c. Water: Nearest 1/10 of a pound per square inch gauge through 100 psig; nearest pound per square inch gauge above 100 psig.

10. Temperature:

a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
b. Outdoor: Nearest degree.
c. Space: Nearest 1/10th of a degree.
d. Chilled Water: Nearest 1/10th of a degree.
e. Heating Hot Water: Nearest degree.

11. Vibration: Nearest 1/10th of an inch per second.
12. Voltage: Nearest 1/10 V up to 100 V; nearest volt above 100 V.

M. Control Stability: Control variables indicated within the following limits:

1. Flow:

a. Air, Ducts and Equipment, except Terminal Units: Within 5 percent of design flow rate.
b. Air, Terminal Units: Within 5 percent of design flow rate.
c. Water: Within 5 percent of design flow rate.

2. Gas:

a. Carbon Dioxide: Within 50 ppm.
b. Carbon Monoxide: Within 5 percent of reading.

3. Moisture (Relative Humidity):

a. Air: Within 5 percent RH.
b. Space: Within 5 percent RH.
c. Outdoor: Within 5 percent RH.

4. Level: Within 5 percent of reading.
5. Pressure:

a. Air, Ducts and Equipment: 1percent of instrument range.
b. Space: Within 1 percent of instrument range
c. Water: Within 1 percent of instrument range.

6. Temperature, Dew Point:

a. Air: Within 1 deg F.
b. Space: Within 1 deg F.

7. Temperature, Dry Bulb:

a. Air: Within 0.5 deg F.
b. Space: Within 0.5 deg F.
c. Chilled Water: Within 1 deg F.
d. Heating Hot Water: Within 1 deg F.

8. Temperature, Wet Bulb:
    a. Air: Within 1 deg F.
    b. Space: Within 1 deg F.

N. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products to operate without performance degradation under ambient environmental temperature, pressure, and humidity conditions encountered for installed location.
    a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure to be internally insulated, electrically heated, cooled, and ventilated as required by product and application.
2. Protect products with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House products not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location dictates the following NEMA 250 enclosure requirements:
    a. Outdoors, Protected: Type 3.
    b. Outdoors, Unprotected: Type 4.
    c. Indoors, Heated and Air-Conditioned: Type 1.
    d. Hazardous Locations: Explosion-proof rating for condition.

O. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators to operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
    a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure is internally insulated, electrically heated and ventilated as required by instrument and application.
2. Protect instruments, actuators, and accessories with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House instruments and actuators not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location is to dictate the following NEMA 250 enclosure requirements:
    a. Outdoors, Protected: Type 3.
    b. Outdoors, Unprotected: Type 4.
    c. Indoors, Heated with Filtered Ventilation: Type 1.
    d. Indoors, Heated and Air-conditioned: Type 1.
    e. Hazardous Locations: Explosion-proof rating for condition.

P. DDC System Reliability:

1. Design, install, and configure DDC controllers, gateways, routers to yield a MTBF of at least 20,000 hours, based on a confidence level of at least 90 percent. MTBF value includes any failure for any reason to any part of products indicated.
2. If required to comply with MTBF indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment being controlled, operational, and under automatic control.
3. See Drawings for critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated.

Q. Electric Power Quality:

1. Power-Line Surges:

   a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.1 and IEEE C62.41.2.
   b. Do not use fuses for surge protection.

2. Power Conditioning:

   a. Protect DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner are as follows:

      1) Provide isolation at all peer-to-peer network terminations, and all field point terminations, to suppress induced voltage transients.

3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products to not fail due to ground fault condition.

R. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems are to automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.5 PANEL-MOUNTED, MANUAL OVERRIDE SWITCHES

A. The operator shall have the ability to manually override any automatic or centrally executed commands at a DDC controller through a local, on-board, on/off/auto override switch for digital control type points, and gradual switches for analog control type points. This override shall be available whether the panel processor itself is operational or not.

1. Provide switches mounted within the DDC controller enclosure, provide key

access to prevent unauthorized overrides.

2. DDC controllers shall have the ability to monitor and record the status of all overrides, and inform the operator that the automatic control has been overridden.
3. DDC controllers shall record and log override activity information, available for reporting.

2.6 SYSTEM ARCHITECTURE

A. System architecture consisting of no more than two levels of LANs.

1. Level 1 LAN: Connect network controllers and operator workstations.
2. Level 2 LAN: Connect programmable application controllers to other programmable application controllers and to network controllers.

B. Minimum Data Transfer and Communication Speed:

1. LAN Connecting Operator Workstations and Network Controllers: 100 Mbps.
2. LAN Connecting Programmable Application Controllers: 1000 kbps.
3. LAN Connecting Application-Specific Controllers: 115,000 bps.

C. Provide dedicated and separated DDC system LANs that are not shared with other building systems and tenant data and communication networks.

D. Provide modular system architecture with inherent ability to expand to not less than 1.5 times system size indicated with no impact to performance indicated.

E. Configure architecture to minimize need to remove and replace existing network equipment for system expansion.

F. Make number of LANs and associated communication transparent to operator. Configure all I/O points residing on any LAN to be capable of global sharing between all system LANs.

G. Design system to eliminate dependence on any single device for system alarm reporting and control execution. Design each controller to operate independently by performing own control, alarm management, and historical data collection.

H. Special Network Architecture Requirements:

1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling-system air-handling unit(s). Basically, create DDC system LAN that aligns with air-handling system being controlled.

2.7 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator able to access entire DDC system through any of multiple means including, but not limited to, the following:

1. Existing Desktop OWS and new portable workstation (POT) with hardwired connection through LAN port.
2. POT with hardwired connection through LAN port.
3. Mobile device and application with secured wireless connection through LAN router or cellular data service.
4. Remote connection through web access.

B. Make access to system, regardless of operator means used, transparent to operator.

C. Network Ports: For hardwired connection of desktop or POT. Network port easily accessible, properly protected, clearly labeled, and installed at the following locations:

1. Mechanical equipment room.
2. Outdoors at existing chiller.
3. Each roof-mounted equipment connected to DDC system.
4. Each VAV and each fan-powered terminal
5. Each zone space sensor.

D. Desktop Workstations:

1. Connect existing OWS to new DDC system Level 1 LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.

E. POT:

1. Connect DDC controller through a communications port local to controller.
2. Able to communicate with any DDC system controller that is directly connected or with LAN.

F. Mobile Device (Tablet and Smart Phone):

1. Connect Owner-furnished mobile devices to system through a wireless router connected to LAN and cellular data service.
2. Able to communicate with any DDC controller connected to DDC system using dedicated application and secure web access.

G. Critical Alarm Reporting:

1. Send operator-selected critical alarms to notify operator of critical alarms that require immediate attention.
2. Send alarm notification to multiple recipients that are assigned for each alarm.
3. Notify recipients by any or all means, including email, text message, and

prerecorded phone message to mobile and landline phone numbers.

H. Simultaneous Operator Use: Capable of accommodating up to five simultaneous operators that are accessing DDC system through any of operator interfaces indicated.

2.8 NETWORKS

A. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:

1. ATA 878.1, ARCNET.
2. CTA-709.1-D.
3. IP.
4. ISO/IEC/IEEE 8802-3, Ethernet.

B. Acceptable networks for connecting programmable application controllers include the following:

1. ATA 878.1, ARCNET.
2. CTA-709.1-D.
3. IP.
4. ISO/IEC/IEEE 8802-3, Ethernet.

C. Acceptable networks for connecting application-specific controllers include the following:

1. ATA 878.1, ARCNET.
2. CTA-709.1-D.
3. TIA 485-A.
4. IP.
5. ISO/IEC/IEEE 8802-3, Ethernet.

2.9 NETWORK COMMUNICATION PROTOCOL

A. Use network communication protocol(s) that are open to Owner and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. Use ASHRAE 135 communication protocol as sole and native protocol used throughout entire DDC system.
2. DDC system to not require use of gateways except to integrate both new and existing HVAC equipment and other building systems and equipment; not required to use ASHRAE 135 communication protocol.
3. If used, gateways to connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Use operator workstations, controllers, and other network devices that are tested

and listed by BTL.

2.10 SYSTEM SOFTWARE

A. Existing front-end software at the existing OWS to remain, and shall operate to the following performance requirements.

B. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system capable of operating DOS and Microsoft Windows applications.
3. Database management software to manage all data on an integrated and non-redundant basis. Additions and deletions to database are to be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software to manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software to include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software to schedule centrally based time and event, temporary, and exception day programs.

C. Operator Interface Software:

1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Make operator sign-off a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Make automatic sign-off period programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Record operator sign-on and sign-off activity and send to printer.
6. Security Access:
    a. Use password control for operator access to DDC system.
    b. Assign an alphanumeric password (field assignable) to each operator.
    c. Grant operators access to DDC system by entry of proper password.
    d. Use same operator password regardless of which computer or other operator interface means are used.

e. Automatically update additions or changes made to passwords.
f. Assign each operator an access level to restrict access to data and functions the operator is cable of performing.
g. Provide software with at least five access levels.
h. Assign each menu item an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
i. Display menu items to operator with those capable of access highlighted. Make menu and operator access level assignments online programmable and under password control.

7. Operators able to perform commands including, but not limited to, the following:

a. Start or stop selected equipment.
b. Adjust set points.
c. Add, modify, and delete time programming.
d. Enable and disable process execution.
e. Lock and unlock alarm reporting for each point.
f. Enable and disable totalization for each point.
g. Enable and disable trending for each point.
h. Override control loop set points.
i. Enter temporary override schedules.
j. Define holiday schedules.
k. Change time and date.
l. Enter and modify analog alarm limits.
m. Enter and modify analog warning limits.
n. View limits.
o. Enable and disable demand limiting.
p. Enable and disable duty cycle.
q. Display logic programming for each control sequence.

8. Reporting:

a. Generated automatically and manually.
b. Sent to displays, printers and disc files.
c. Types of Reporting:

1) General listing of points.
2) List points currently in alarm.
3) List of off-line points.
4) List points currently in override status.
5) List of disabled points.
6) List points currently locked out.
7) List of items defined in a "Follow-Up" file.
8) List weekly schedules.
9) List holiday programming.
10) List of limits and deadbands.

9. Summaries: For specific points, for a logical point group, for an operator selected

group(s), or for entire system without restriction due to hardware configuration.

D. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface is to use a pointing device with pull-down or penetrating menus, color, and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
4. Make descriptors for graphics, points, alarms, and such modifiable through operator's workstation under password control.
5. Make graphic displays online user definable and modifiable using the hardware and software provided.
6. Make data displayed within a graphic assignable regardless of physical hardware address, communication, or point type.
7. Make graphics online programmable and under password control.
8. Make points assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics to also contain software points.
10. Penetration within a graphic hierarchy is to display each graphic name as graphics are selected to facilitate operator understanding.
11. Provide a back-trace feature to permit operator to move upward in the hierarchy using a pointing device. Back trace to show all previous penetration levels. Include operator with option of showing each graphic full-screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Provide operator with ability to select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Display defined and linked graphic below that selection.
14. Include operator with means to directly access graphics without going through penetration path.
15. Make dynamic data assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
17. Use color, rotation, or other highly visible means, to denote status and alarm states. Make colors variable for each class of points, as chosen by operator.
18. Provide dynamic points with operator adjustable update rates on a per point basis from one second to over a minute.
19. For operators with appropriate privilege, command points directly from display

using pointing device.

a. For an analog command point such as set point, display current conditions and limits so operator can position new set point using pointing device.
b. For a digital command point such as valve position, show valve in current state such as open or closed so operator could select alternative position using pointing device.
c. Include a keyboard equivalent for those operators with that preference.

20. Give operator ability to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot, and other information on other quadrants on screen. This feature allows real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
21. Help Features:

a. Online context-sensitive help utility to facilitate operator training and understanding.
b. Bridge to further explanation of selected keywords and contain text and graphics to clarify system operation.

1) If help feature does not have ability to bridge on keywords for more information, provide a complete set of user manuals in an indexed word-processing program, which runs concurrently with operating system software.

c. Available for Every Menu Item:

1) Index items for each system menu item.

22. Provide graphic generation software to allow operator ability to add, modify, or delete system graphic displays.

a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols[similar to those indicated].
b. Use a pointing device in conjunction with a drawing program to allow operator to perform the following:

1) Define background screens.
2) Define connecting lines and curves.
3) Locate, orient, and size descriptive text.
4) Define and display colors for all elements.
5) Establish correlation between symbols or text and associated system points or other displays.

E. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing building, and additional site elements, outdoor equipment, which are being controlled or monitored by DDC system.

2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:

   a. Room layouts with room identification and name.
   b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
   c. Location and identification of each hardware point being controlled or monitored by DDC system.
   d. Locations of all sensing devices, tagged.

      1) Record exact location of hydronic piping loop differential pressure transmitters on respective system graphics
      2) exact record exact location of duct static pressure sensor and transmitter on respective system graphic
      3) identify devices above ceilings based upon nearest room location (room name/ number)

3. Control schematic for each of following, including a graphic system schematic representation, similar to that indicated on Drawings, with point identification, set point and dynamic value indication, sequence of operation summary.
4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways, OWS, other network devices.

F. Customizing Software:

1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
3. At a minimum, include the following modification capability:

   a. Operator Assignment: Designation of operator passwords, access levels, point segregation, and auto sign-off.
   b. Peripheral Assignment: Assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points, and enabling and disabling of print-out of operator changes.
   c. System Configuration and Diagnostics; Communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points, and application programs and initiation of diagnostics.

d. System Text Addition and Change: English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time, and trouble condition.
e. Time and Schedule Change: Time and date set, time and occupancy schedules, exception and holiday schedules, and daylight-savings time schedules.
f. Point related change capability is to include the following:

1) System and point enable and disable.
2) Run-time enable and disable.
3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
4) Assignment of alarm and warning limits.

g. Application program change capability is to include the following:

1) Enable and disable of software programs.
2) Programming changes.
3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

4. Provide software to allow operator ability to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Make additions and modifications online programmable using operator workstations, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, upload and record database on hard drive and disc for archived record.
5. Include high-level language programming software capability for implementation of custom DDC programs. Include a compiler, linker, and up- and down-load capability.
6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic, and relational operators for implementation of control sequences. Also include, at a minimum, the following:

a. Proportional control (P).
b. Proportional plus integral (PI).
c. Proportional plus integral plus derivative (PID).
d. Adaptive and intelligent self-learning control.

1) Algorithm monitors loop response to output corrections and adjust loop response characteristics in accordance with time constant changes imposed.
2) Algorithm operates in a continuous self-learning manner and retains in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

G. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and

transmitted through DDC controllers, gateways and other network devices.

2. Include first in, first out handling of alarms in accordance with alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Make alarm handling active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display is to include the following:
    a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
    b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
    c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
    d. Include extended message capability to allow assignment and printing of extended action messages. Capability is to be operator programmable and assignable on a per point basis.
5. Direct alarms to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
6. Send email alarm messages to designated operators for critical alarms.
7. Send email, page, text, and voice messages to designated operators for critical alarms.
8. Categorize and process alarms by class.
    a. Class 1:
        1) Associated with fire, security, and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
        2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
        3) All conditions make an audible alarm sound and require individual acknowledgment to silence audible sound.
    b. Class 2:
        1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
        2) Acknowledgement may be through a multiple alarm acknowledgment.
    c. Class 3:
        1) General alarms; printed, displayed, and placed in unacknowledged alarm buffer queues.
        2) Configure so each new alarm received makes an audible alarm sound that are silenced by "acknowledging" alarm or by pressing a "silence" key.

3) Make acknowledgement of queued alarms either on an individual basis or through a multiple alarm acknowledgement.
4) Print alarms returning to normal condition without an audible alarm sound or require acknowledgment.

d. Class 4:

1) Routine maintenance or other types of warning alarms.
2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.

H. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Setup each report so data content, format, interval, and date are operator definable.
3. Sample and store report data on DDC controller, within storage limits of DDC controller, and then uploaded to archive on the OWS for historical reporting.
4. Make it possible for operators to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Store reports and logs on OWS hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6. Make reports and logs readily printable and set to be print either on operator command or at a specific time each day.

I. Standard Reports: Provide standard DDC system reports with operator ability to customize reports later.

1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:

a. Alarm history.
b. System messages.
c. System events.
d. Trends.

J. Custom Reports: Operator able to easily define and prepare any system data into a daily, weekly, monthly, annual, or other historical report. Reports to include a title with time and date stamp.

K. HVAC Equipment Reports: Prepare Project-specific reports.

1. Chiller Report: Daily report showing operating conditions of each chiller in accordance with ASHRAE 147 including, but not limited to, the following:

   a. Chilled-water entering temperature.
   b. Chilled-water leaving temperature.
   c. Chilled-water flow rate.
   d. Times and hours for run of each compressor
   e. Chiller percent load
   f. Pump times and hours for run of each pump
   g. Percent of full speed for each pump
   h. Motor amperes per phase.
   i. Motor volts per phase.
   j. Ambient temperature (dry bulb and wet bulb).
   k. Chiller alarms
   l. Date and time logged.

2. Boiler Reports:

   a. Heating hot-water entering temperature.
   b. Heating hot-water leaving temperature.
   c. Heating hot water flow rate.
   d. Times and hours for run of each boiler
   e. boiler percent load
   f. Pump times and hours for run of each secondary pump
   g. Percent of full speed for each secondary pump
   h. Ambient temperature (dry bulb and wet bulb).
   i. Boiler alarms
   j. Date and time logged.

3. Zone Reports:

   a. Space temperature and humidity setpoints
   b. Space actual temperatures and humidity
   c. Primary air flow rates
   d. Reheat valve percent open
   e. Any zone alarms

4. Air-Handler Reports:

   a. Percent supply fan speed
   b. Percent return fan speed
   c. Percent economizer operation (return/outdoor air damper positions)
   d. Outdoor air flow (where airflow station is applied)
   e. Chilled water control valve percent open
   f. Heating hot Water control valve percent open
   g. Mixed air temperature

h. Heating hot water leaving air temperature
i. Unit supply air temperature

L. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Associate trends into groups, and setup a trend report for each group.
3. Store trends within DDC controller and uploaded to hard drives automatically on reaching 75 percent of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Make trend intervals operator selectable from 10 seconds up to 60 minutes. Make minimum number of consecutive trend values stored at one time 100 per variable.
6. When drive storage memory is full, overwrite oldest data with most recent data.
7. Make archived and real-time trend data available for viewing numerically and graphically by operators.

M. Custom Trends: Operator-definable custom trend log for any I/O point in DDC system.

1. Include each trend with interval, start time, and stop time.
2. Sample and store data on DDC controller, within reaching 75 percent storage limits of DDC controller, and then uploaded to archive on existing OWS hard drives.
3. Make data retrievable for use in spreadsheets and standard database programs.

N. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programming software is to be as follows:

   a. Graphic Based: Use a library of function blocks made from preprogrammed code designed for DDC control systems.

      1) Assemble function blocks with interconnection lines that represent to control sequence in a flowchart.
      2) Make programming tools viewable in real time to show present values and logical results of each function block.

   b. Menu Based: Done by entering parameters, definitions, conditions, requirements, and constraints.
   c. Line by Line and Text Based: Programming is to declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.
5. Monitoring settings taskbar with following informational icons:
    a. Normal: Indicates by color and size, or other easily identifiable means, that all databases are within their limits.
    b. Warning: Indicates by color and size, or other easily identifiable means, that one or more databases have exceeded their warning limit.
    c. Alarm: Indicates by color and size, or other easily identifiable means, that one or more databases have exceeded their alarm limit.

2.11 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, air-terminal units, relief fans, and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems where indicated, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:
    1. Read and view all readable object properties on non-BACnet network to BACnet network, and vice versa, where applicable.
    2. Write to all writable object properties on non-BACnet network from BACnet network, and vice versa, where applicable.
    3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet, and vice versa.
    4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs in accordance with ASHRAE 135.
    5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
    6. Backup programming and parameters on CD media with ability to modify, download, backup, and restore gateway configuration.

2.12 DDC CONTROLLERS

A. DDC system consisting of a combination of the existing JACE building controller to remain, and new programmable application controllers, and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers to perform monitoring, control, energy optimization, and other requirements indicated.

C. DDC controllers are to use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller is capable of full and complete operation as a completely independent unit and as a part of DDC system wide distributed network.

E. Environment Requirements:

1. Controller hardware suitable for anticipated ambient conditions.
2. Controllers located in conditioned space rated for operation at 32 to 120 deg F temperature range.
3. Controllers located outdoors rated for operation at -20 to 150 deg F temperature range.

F. Power and Noise Immunity:

1. Operate controller at 90 to 110 percent of nominal voltage rating and perform an orderly shutdown below 80 percent of nominal voltage.
2. Protect against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

G. DDC Controller Spare Processing Capacity:

1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:

   a. Network Controllers: 50 percent.
   b. Programmable Application Controllers: Not less than 60 percent.
   c. Application-Specific Controllers: Not less than 70 percent.

2. Memory for DDC controller's operating system and database are to include the following:

   a. Monitoring and control.
   b. Energy management, operation, and optimization applications.
   c. Alarm management.
   d. Historical trend data of all connected I/O points.
   e. Maintenance applications.
   f. Operator interfaces.
   g. Monitoring of manual overrides.

H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

1. Network Controllers:

a. 20 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: Three
2) AOs: Three.
3) BIs: Four.
4) BOs: Four
5) Option to provide universal I/O to meet spare requirements.

2. Programmable Application Controllers:

a. 20 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: Three.
2) AOs: Three.
3) BIs: Four.
4) BOs: Four.
5) Option to provide universal I/O to meet spare requirements.

3. Application-Specific Controllers:

a. 20 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: Two.
2) AOs: two.
3) BIs: Two.
4) BOs: two.
5) Option to provide universal I/O to meet spare requirements.

I. Maintenance and Support: Include the following features to facilitate maintenance and support:

1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

J. I/O Point Interface:

1. Connect hardwired I/O points to network, programmable application, and application-specific controllers.
2. Protect I/O points so shorting of point to itself, to another point, or to ground will not damage controller.
3. Protect I/O points from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:

a. Include monitoring of low-voltage (0 to 10 V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.

b. Compatible with, and field configurable to, sensor and transmitters installed.
c. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 10 bits or better to comply with accuracy requirements indicated.
d. Signal conditioning including transient rejection for each AI.
e. Capable of being individually calibrated for zero and span.
f. Incorporate common-mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
g. External conversion resistors are not permitted.

5. AOs:

a. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 10 bits or better to comply with accuracy requirements indicated.
b. Output signals range of 4 to 20 mA dc, 0 to 10 V dc, or as otherwise required to include proper control of output device.
c. Capable of being individually calibrated for zero and span.
d. Drift is to be not greater than 0.4 percent of range per year.
e. External conversion resistors are not permitted.

6. BIs:

a. Accept contact closures and ignore transients of less than 5 ms duration.
b. Isolate and protect against an applied steady-state voltage of up to 180 V ac peak.
c. Include a wetting current of at least 12 mA to be compatible with commonly available control devices and protected against effects of contact bounce and noise.
d. Sense "dry contact" closure without external power (other than that provided by controller) being applied.
e. Pulse accumulation input points complying with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Include buffer to totalize pulses. Pulse accumulator is to accept rates of at least 20 pulses per second. Reset the totalized value to zero on operator's command.

7. BOs:

a. Include relay contact closures or triac outputs for momentary and maintained operation of output devices.

1) Relay contact closures to have a minimum duration of 0.1 second and at least 180 V of isolation.
2) Include electromagnetic interference suppression on all output lines to limit transients to non-damaging levels.
3) Minimum contact rating to be 1 A at 24 V ac.
4) Triac outputs to have at least 180 V of isolation and minimum contact rating of 1 A at 24 V ac.

b. Include BOs with two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
c. BOs to be selectable for either normally open or normally closed operation.
d. Include tristate outputs (two coordinated BOs) for control of three-point, floating-type electronic actuators without feedback.
e. Limit use of three-point floating devices to VAV terminal unit control applications. Control algorithms to operate actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.13 PROGRAMMABLE APPLICATION CONTROLLERS

A. General:

1. Include adequate number of controllers to achieve performance indicated.
2. Provide enough memory to support its operating system, database, and programming requirements with spare memory indicated.
3. Share data between networked controllers and other network devices.
4. Include controller with operating system to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Scheduling with a real-time clock to be communicated to the application controller from the existing OWS through the existing network controller.
6. Controller is to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller assumes a predetermined failure mode and generates an alarm notification.
7. Fully programmable.

B. Communication:

1. Programmable application controllers are to communicate with other devices on network.

C. Operator Interface:

1. Equip controllers with a service communications port for connection to POT or mobile device. Local Keypad and Display:

a. Equip controller with local keypad and digital display for interrogating and editing data.
b. Protect use of keypad and display by security password.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain BIOS and programming information in event of power loss for at least 72 hours.

2.14 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment or system. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and continued control functions without being connected to network.
2. Share data between application controllers, network controller and other network devices.

B. Communication: Application-specific controllers are to communicate with other application-specific controllers and devices on network, and to programmable application controllers and network controllers.

C. Operator Interface: Equip controllers with a service communications port for connection to POT or mobile device. Connection is to extend to port on space temperature sensor that is connected to controller.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.15 CONTROLLER SOFTWARE

A. General:

1. Software applications are to reside and operate in controllers. Edit applications through operator workstations or mobile devices.
2. Identify I/O points by up to 30 character point name and up to 16 character point descriptor. Use same names throughout, including at operator workstations.
3. Execute control functions within controllers using DDC algorithms.
4. Configure controllers to use stored default values to ensure fail-safe operation. Use default values when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Secure operator access using individual security passwords and user names.
2. Passwords restrict operator to points, applications, and system functions as assigned by system manager.
3. Record operator log-on and log-off attempts.

4. Protect from unauthorized use by automatically logging off after last keystroke. Make the delay time operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule is to consist of the following:

1. Weekly Schedule:
   a. Include separate schedules for each day of week.
   b. Each schedule should include capability for start, stop, optimal start, optimal stop, and night economizer.
   c. Each schedule may consist of up to 10 events.
   d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.
2. Exception Schedules:
   a. Include ability for operator to designate any day of the year as an exception schedule.
   b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.
3. Holiday Schedules:
   a. Include capability for operator to define up to 99 special or holiday schedules.
   b. Place schedules on scheduling calendar with ability to repeated each year.
   c. Operator able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.
2. Include operator with a method of grouping together equipment based on function and location.
3. Include groups that may be for use in scheduling and other applications.

E. Binary Alarms:

1. Set each binary point to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:

1. Provide each analog object with both high and low alarm limits.
2. Include capability to automatically and manually disable alarming.

G. Alarm Reporting:

1. Include ability for operators to determine action to be taken in event of an alarm.
2. Route alarms to appropriate operator workstations based on time and other conditions.

3. Include ability for alarms to start programs, print, be logged in event logs, generate custom messages, and display graphics.

H. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

I. Control Loops:

1. Support any of the following control loops, as applicable to control required:

a. Two-position (on/off, open/close, slow/fast) control.
b. Proportional control.
c. Proportional plus integral (PI) control.
d. Proportional plus integral plus derivative (PID) control.

1) Include PID algorithms with direct or reverse action and anti-windup.
2) Algorithm to calculate a time-varying analog value used to position an output or stage a series of outputs.
3) Make controlled variable, set point, and PID gains operator-selectable.

e. Adaptive (automatic tuning).

J. Staggered Start: Prevent all controlled equipment from simultaneously restarting after a power outage. Make the order which equipment (or groups of equipment) is started, along with the time delay between starts, operator-selectable.

K. Anti-Short Cycling:

1. Protect BO points from short cycling.
2. Feature to allow minimum on-time and off-time to be selected.

L. On and Off Control with Differential:

1. Include algorithm that allows BO to be cycled based on a controlled variable and set point.
2. Use direct- or reverse-acting algorithm and incorporate an adjustable differential.

M. Run-Time Totalization:

1. Include software to totalize run-times for all BI [and BO]points.
2. Assign a high run-time alarm, if required, by operator.

2.16 ENCLOSURES

A. General:

1. House each controller and associated control accessories in enclosure. Enclosure is to serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies, and transformers.
2. Include enclosure door with key locking mechanism. Key locks alike for all

enclosures and include one pair of keys per enclosure.
3. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
4. Individual, wall-mounted, single-door enclosures maximum of 36 inches wide and 48 inches high.
5. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
6. Supply each enclosure with complete set of as-built schematics, tubing, and wiring diagrams and product literature located in pocket on inside of door. For enclosures with windows, include pocket on bottom of enclosure.
7. Coordinate closely with the Construction Manager and other trades for determining locations for controls enclosures.

B. Internal Arrangement:

1. Arrange internal layout of enclosure to group and protect electric, and electronic components associated with controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling, and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include enclosure field electric power supply with toggle-type switch located at entrance inside enclosure to disconnect power.
7. Include enclosure with line-voltage nominal 20 A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with 5 A circuit breaker.
8. Mount products within enclosure on removable internal panel(s).
9. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). Nameplates are to have at least 1/2-inch- high lettering.
10. Route tubing cable and wire located inside enclosure within a raceway with continuous removable cover.
11. Label each end of cable, wire, and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
12. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Wall-Mounted, NEMA 250, Type 1:

1. NRTL listed in accordance with UL 50 or UL 50E.
2. Construct enclosure of steel, not less than the following:
    a. Enclosure Size Less Than 24 Inches: 0.053 inch thick.

b. Enclosure Size 24 Inches and Larger: 0.067 inch thick.

3. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

   a. Exterior Color: Manufacturer's standard.
   b. Interior Color: Manufacturer's standard.

4. Hinged door full size of front face of enclosure and supported using the following:

   a. Enclosures Sizes Less Than 36 Inches Tall: Multiple butt hinges.
   b. Enclosures Sizes 36 Inches Tall and Larger: Continuous piano hinges.

5. Removable internal panel with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

   a. Size Less Than 24 Inches: perforated steel, 0.053 inch thick.
   b. Size 24 Inches and Larger: Solid aluminum, 0.10 inch or steel, 0.093 inch thick.

6. Internal panel mounting hardware, grounding hardware, and sealing washers.
7. Grounding stud on enclosure body.
8. Thermoplastic pocket on inside of door for record Drawings and Product Data.

2.17 RELAYS

A. General-Purpose Relays:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Allen Bradley; by Rockwell Automation
   b. Eaton
   c. IDEC Corporation
   d. Omron Americas
   e. Siemens Industry, Inc., Building Technologies Division
   f. Square D; Schneider Electric USA

2. NRTL listed.
3. Heavy-duty, electromechanical type; rated for at least 10A at 250 V ac and 60 Hz.
4. SPDT, DPDT, or three-pole double-throw, as required by control application.
5. Plug-in-style relay with multiblade plug for DPDT relays and multiblade plug for three-pole double-throw relays.
6. Construct contacts of silver, silver alloy, or gold.
7. Enclose relay in a clear transparent polycarbonate dust-tight cover.
8. Include LED indication and push-to-test button to test manual operation of relay without power on coil.
9. Performance:

   a. Mechanical Life: At least 10 million cycles.

b. Electrical Life: At least 100,000 cycles at rated load.
c. Pickup Time: 20 ms or less.
d. Dropout Time: 20 ms or less.
e. Pull-in Voltage: 85 percent of rated voltage.
f. Dropout Voltage: 50 percent of nominal rated voltage.
g. Power Consumption: 5 VA or less.
h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

10. Equip relays with coil transient suppression to limit transients to non-damaging levels.
11. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
12. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

B. Current Sensing Relays:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Eaton
b. Functional Devices Inc
c. NK Technologies
d. Square D; Schneider Electric USA
e. Veris Industries

2. NRTL listed.
3. Monitors ac current.
4. Independent adjustable controls for pickup and dropout current.
5. Energized when supply voltage is present and current is above pickup setting.
6. De-energizes when monitored current is below dropout current.
7. Dropout current is adjustable from 50 percent of pickup current.
8. Visual indication of contact status.
9. Include current transformer, if required for application.
10. House current sensing relay and current transformer if required in its own enclosure. Use NEMA 250, Type 1 or Type 12 enclosure for indoors applications and NEMA 250, Type 4 or Type 4X for outdoor applications.

C. Combination On-Off Status Sensor and On-Off Control Relays:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Functional Devices Inc
b. Veris Industries

2. Description:

a. On-off control and on-off status indication in a single device.
b. LED status indication of activated relay and current trigger.
c. Closed-Open-Auto override switch located on the load side of relay.

3. Performance:

a. Ambient Temperature: Minus 30 to 140 deg F.
b. Voltage Rating: Single-phase loads rated for 300 V ac. Three-phase loads rated for 600 V ac.

4. Status Indication:

a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
b. Current Sensor Range: As required by application.
c. Current Set Point: Adjustable as required by application.
d. Current Sensor Output:

1) Solid-state, SPDT contact rated for 30 V ac and dc and for 0.4 A.
2) Solid-state, SPDT contact rated for 120 V ac and 1.0 A.
3) Analog, 0 to 5 or 10 V dc.
4) Analog, 4 to 20 mA, loop powered.

5. Relay: SPDT, continuous-duty coil; rated for 10-million mechanical cycles.
6. Enclosure: NEMA 250, Type 1 or Type 12 enclosure for indoor applications; NEMA 250, Type 4 or Type 4X enclosure for outdoor applications.

2.18 ELECTRICAL POWER DEVICES

A. Control Transformers:

1. Sizing Criteria: Size control transformers for total connected load, plus additional 50 percent of connected load for future spare capacity.
2. Transformer Minimum Capacity: 40 VA.
3. Protection: Provide transformers with both primary and secondary fuses. Integral circuit breaker is acceptable in lieu of fuses.
4. Enclosure: House control transformers in NEMA 250 enclosures, type as indicated in "Performance Requirements" Article for application.

B. DC Power Supplies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Acopian Technical Company
b. Emerson Electric Co., Automation Solutions
c. IDEC Corporation
d. Omron Americas

2. Description: Linear or switched, regulated power supplies with ac input to one or multiple dc output(s).

a. Include both line and load regulation to ensure stable output.
b. To protect both power supply and load, include power supply with an automatic current limiting circuit.

3. Features:

a. Connection: Plug-in style suitable for mating with standard 8-pin octal socket. Include power supply with mating mounting socket.
b. Housing: Enclose circuitry in a housing.
c. Local Adjustment: Include screw adjustment on exterior of housing for dc voltage output.
d. Mounting: DIN rail.
e. Visual status indicator.

4. Performance:

a. Input Voltage: Nominally 120 V ac, 60 Hz.
b. Output Voltage: Nominally 24 V dc with plus or minus 1 V dc adjustment.
c. Output Current: Minimum 100 mA.
d. Load Regulation: Within 0.1 percent.
e. Line Regulation: Within 0.05 percent.
f. Stability: Within 0.1 percent of rated volts after warmup period.
g. Ripple: 1 mV rms.

2.19 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

1. Wire Size: Minimum 18 AWG.
2. Conductors: 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
3. Conductor Insulation: 600 V, Type THWN or Type THHN, and 90 deg C in accordance with UL 83.
4. Conductor Insulation Colors: Black (hot), white (neutral), and green (ground).
5. Furnish on spools.

B. Single, Twisted-Shielded, Instrumentation Cable above 24 V:

1. Wire Size: Minimum 18 AWG.
2. Conductors: Twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
3. Conductor Insulation: Type THHN/THWN or Type TFN rating.
4. Conductor Insulation Colors:

a. Twisted Pair: Black and white.
b. Twisted Triad: Black, red, and white.

5. Shielding: 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
6. Outer Jacket Insulation: 600 V, 90 deg C rating, and Type TC cable.
7. Furnish on spools.

C. Single, Twisted-Shielded, Instrumentation Cable 24 V and Less:

1. Wire Size: Minimum 18 AWG.
2. Conductors: Twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor Insulation: Nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Conductor Insulation Colors:

   a. Twisted Pair: Black and white.
   b. Twisted Triad: Black, red, and white.

5. Shielding: 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
6. Outer Jacket Insulation: 300 V, 105 deg C rating, and Type PLTC cable.
7. Furnish on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Comply with following requirements for balanced twisted pair cable described in Division 26 specifications

   a. Plenum rated.
   b. Unique color that is different from other cables used on Project.

2.20 RACEWAYS

A. Comply with requirements in Division 26 specifications for raceway and boxes for electrical systems, for electrical power raceways and boxes.

B. Comply with requirements in Division 27 specification sections for pathways for communications systems, for raceways for balanced twisted pair cables and optical fiber cables.

2.21 ACCESSORIES

A. I/P and E/P Transducers:

1. Commercial Grade:

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

      1) ControlAir, Inc.
      2) Dwyer Instruments, Inc
      3) KMC Controls, Inc.
      4) MAMAC Systems, Inc.

   b. Features:

1) Auto/manual output switch, manual output control, and output pressure gauge.
2) Separate zero and span calibration adjustments.

c. Performance:

1) Accuracy: Within 1.0 percent of output span.
2) Linearity: Within 0.5 percent of output span.
3) Vibration: Construct entire assembly so that shock and vibration will not harm transducer or affect accuracy.

2.22 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Self-adhesive label, Laminated acrylic or melamine plastic sign, bearing unique identification.

a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Letter size as follows:

a. Servers: Minimum of 0.5 inch high.
b. DDC Controllers: Minimum of 0.5 inch high.
c. Gateways: Minimum of 0.5 inch high.
d. Repeaters: Minimum of 0.5 inch high.
e. Enclosures: Minimum of 0.5 inch high.
f. Electrical Power Devices: Minimum of 0.5 inch high.
g. Accessories: Minimum of 0.5 inch high.
h. Instruments: Minimum of 0.5 inch.
i. Control Damper and Valve Actuators: Minimum of 0.5 inch.

3. Engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers color-coded black with contrasting white center exposed by engraving through outer layer.
4. Fastened with drive pins.
5. Instruments, control devices, and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

B. Valve Tags:

1. Brass tags and brass chains attached to valve.
2. Tag Size: Minimum 1.5 inches in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer

do not require an additional tag.

C. Raceway and Boxes:

1. Comply with requirements for identification specified in Division 26 specifications Identification for Electrical Systems.

D. Equipment Warning Labels:

1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size at least 14-point type with white lettering on red background.
3. Warning label to read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering to be enclosed in a white line border. Edge of label is to extend at least 0.25 inch beyond white border.

2.23 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate the following in accordance with industry standards for each product, and to verify DDC system reliability specified in performance requirements:

1. DDC controllers.
2. Gateways.
3. Routers.
4. Application Controllers
5. Application-specific controllers
6. Sensors and operators
7. Programming.

B. Control system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

E. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

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

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

1. DDC system shall be provided with communication interface for remote monitoring and/or control of/with both existing and new equipment having integral manufacturer controls for remote monitoring or control to BAS.
2. Equipment to Be Connected:

   a. Fan-powered air-terminal units and variable air volume terminal units
   b. Boilers and associated primary and secondary pumps
   c. Chillers and associated system pumps
   d. Air-handling units outdoors
   e. Air-handling units indoors
   f. Cabinet heaters and unit heaters
   g. Exhaust and relief fans
   h. Packaged gas-electric roof-top units
   i. Ductless split heat pump units
   j. Computer-room air-conditioning units
   k. Electric resistance heaters
   l. Variable-frequency drives-speed controllers.
   m. Domestic hot water recirculation pumps.
   n. Automated glycol-feeders

3.3 PREINSTALLATION INTEGRATION TESTING

A. Perform the following pretesting of existing and other systems/equipment integration with DDC system before developing system design and submittals:

1. Test all communications in a controlled environment to ensure connectivity.
2. Load software and demonstrate functional compliance with each control sequence of operation indicated.
3. Using simulation, demonstrate compliance with sequences of operation and other requirements indicated including, but not limited to, the following:

   a. HVAC equipment controlled through DDC system, such as boilers, chillers, pumps, and air-handling units.

b. Equipment faults and system recovery with fault annunciation.
c. Analog and Boolean value alarming and annunciation.

4. Develop a method for testing interfaces before deployment.
5. Submit documentation supporting compliance upon request.
6. Submit report on results of testing.

3.4 DDC SYSTEM INTERFACE WITH EXISTING SYSTEMS

A. Interface with Existing Systems:

1. Provide Interface for BAS with existing systems to achieve integration indicated.
2. Monitoring and Control of DDC System by Existing Control System:

a. Satisfy DDC system performance requirements when monitoring and controlling DDC system by existing control system.
b. Operator of existing system to upload, download, monitor, trend, control, and program every I/O point in DDC system from existing control system using existing control system software and operator workstations.
c. Make interface so operator of existing system is not required to learn new software for remote monitoring and control from existing control system.
d. Make interface of DDC system into existing control system transparent to operators of existing control system and allow operators to program, monitor, and control DDC system from any operator workstation connected to existing control system.

3. Provide Integration of Existing Control System into BAS System:

a. Satisfy existing control system performance requirements when monitoring and controlling existing control system through DDC system.
b. Operator to upload, download, monitor, alarm, report, trend, control, and program every I/O point in existing system from DDC system using operator workstations and software provided. Combined systems to share one database.
c. Make interface of existing control system I/O points into DDC system transparent to operators. Make all operational capabilities identical regardless of whether I/O already exists, or I/O is being installed.

3.5 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. Control dampers

2. Airflow sensors and switches
3. Pressure sensors
4. Temperature and humidity level air sensors

C. Deliver the following to HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. Control valves.
2. Pipe-mounted flow meters
3. Pipe-mounted sensors, switches, and transmitters.
4. Tank-mounted sensors, switches, and transmitters.
5. Liquid temperature sensors, switches, and transmitters.
6. Pipe- and tank-mounted thermowells. Liquid thermowells.

3.6 CONTROL DEVICES FOR EQUIPMENT MANUFACTURER FACTORY INSTALLATION

A. Deliver the following to terminal unit manufacturer for factory installation. Include installation instructions to terminal unit manufacturer.

1. Application-specific controller.
2. Electric damper actuator.
3. Unit-mounted flow and pressure sensors, transmitters, and transducers.
4. Unit-mounted temperature sensors.

3.7 GENERAL INSTALLATION REQUIREMENTS

A. Provide products to satisfy more stringent of all requirements indicated on drawings, specifications and recommendations of control manufacturers and controlled equipment manufacturers.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring, and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to force.

D. If codes and referenced standards are more stringent than requirements indicated, provide to comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Division 7 specifications

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Division 7 specifications.

H. Fastening Hardware:

1. Wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

I. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

J. Environments for accelerated degradation:

1. Avoid or limit use of materials in corrosive airstreams and environments including, but not limited to, the following:
   a. Laboratory exhaust-air streams.
   b. Process exhaust-air streams.
   c. Outdoors.
2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for installation of raceways and boxes specified in Division 26 specification sections.
3. Where instruments are located in a corrosive airstream and are not already corrosive resistant from instrument manufacturer, field install products in NEMA 250, Type 4X instrument enclosure constructed of Type 316L stainless steel.

3.8 INSTALLATION OF WORKSTATIONS

A. Portable Workstation Installation:

1. Install DDC system software on new POT and verify that software functions properly.

B. Color Graphics Application:

1. Use system schematics indicated on Drawings as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.

4. Confirm final naming conventions, room names and numbers, equipment identifiers, with Owner and architect before developing graphics.
5. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Architect's review before creating graphic using graphics software.
6. Seek Owner input in graphics development once using graphics software.
7. Make final editing on-site with Owner's and Architect's review and feedback.
8. Refine graphics as necessary for Owner acceptance.
9. On receiving Owner acceptance, print a PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.9 INSTALLATION OF POT

A. Provide one POT to Owner

B. Turn over POTs to Owner at Substantial Completion.

C. Install software on each POT and verify that software functions properly.

3.10 INSTALLATION OF GATEWAYS

A. Install gateways where required for DDC system communication interface requirements indicated herein.

B. Test gateways to verify that communication interface functions properly.

C. Test routers to verify that communication interface functions properly.

3.11 INSTALLATION OF CONTROLLERS

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply and to UPS units where indicated.

C. Install controllers with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of network controllers to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Locate top of controller within 72 inches of finished floor for ease of access.

F. Installation of Programmable Application Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of programmable application controllers to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Locate top of controller within 72 inches of finished floor.
4. Where Application Controllers are dedicated to equipment, install within equipment manufacturer controls cabinet enclosure.

G. Application-Specific Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of application-specific controllers to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.
3. Where Application-specific controllers are dedicated to terminal equipment, install within the manufacturer’s controls box/enclosure.

3.12 INSTALLATION OF ENCLOSURES

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Routers.
3. Controllers.
4. Electrical power devices.
5. Relays.
6. Accessories.
7. Instruments.

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, Type 1 Enclosures: Use painted steel strut and hardware.
2. For NEMA 250, Type 4 or Type 4X Enclosures and Enclosures Located Outdoors: Use stainless steel strut and hardware.
3. Install plastic caps on exposed cut edges of strut.

C. Align top or bottom of adjacent enclosures of like size.

D. Install floor-mounted enclosures located in mechanical equipment rooms on concrete housekeeping pads. Attach enclosure legs using galvanized-steel or stainless steel anchors.

E. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireways used for application are to have protection equal to NEMA 250 rating of connected enclosures.

3.13 ELECTRIC POWER CONNECTIONS

A. This contractor shall provide all components and devices necessary for a complete and operable DDC system as specified herein

B. Provide final electrical connections at DDC panels, connect to 120 V AC power provided by division 26 electrical contractor.

C. Each control panel shall include a dedicated circuit breaker. All 24 V power required for operation of the controls system shall be by the Temperature Controls contractor.

D. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade to provide a fully functioning DDC system. Work is to comply with NFPA 70 and other requirements indicated.

E. Comply with requirements in Division 26 sections for enclosed switches and circuit breakers for electrical power circuit breakers.

F. Comply with requirements in Division 26 sections for Low-Voltage Electrical Power Conductors and Cables for electrical power conductors and cables.

G. Comply with requirements in Division 26 sections for Raceway and Boxes for Electrical Systems for electrical power raceways and boxes.

3.14 INSTALLATION OF IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Division 26 sections for identification for electrical systems for identification products and installation.

B. Install self-adhesive labels, laminated acrylic or melamine plastic signs, with unique identification on face for each of the following:

1. Server.
2. Gateway.
3. Router.
4. DDC controller.
5. Enclosure.
6. Electrical power device.
7. Accessory.

C. Install unique instrument identification for each instrument connected to DDC controller.

D. Install unique identification for each control damper and valve actuator connected to DDC controller.

E. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.

F. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.

G. Warning Labels and Signs:

1. Permanently attach to equipment that can be automatically started by DDC control system.
2. Locate where highly visible near power service entry points.

3.15 INSTALLATION OF NETWORKS

A. Install balanced twisted pair or optical fiber cable when connecting between the following network devices located in same building:

1. Operator workstations.
2. Operator workstations and network controllers.
3. Network controllers.

B. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:

1. Gateways.
2. Gateways and network controllers or programmable application controllers.
3. Routers.
4. Routers and network controllers or programmable application controllers.
5. Network controllers and programmable application controllers.
6. Programmable application controllers.
7. Programmable application controllers and application-specific controllers.
8. Application-specific controllers.

C. Install cable in continuous raceway.

1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.16 NETWORK NAMING AND NUMBERING

A. ASHRAE 135 Networks:

1. MAC Address:

   a. Assign and document a MAC address unique to its network for every network device.
   b. Ethernet Networks: Document MAC address assigned at its creation.
   c. MS/TP Networks: Assign from 00 to 64.

2. Network Numbering:

a. Assign unique numbers to each new network.
b. Provide ability for changing network number through device switches or operator interface.
c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

3. Device Object Identifier Property Number:

a. Assign unique device object identifier property numbers or device instances for each device network.
b. Provide for future modification of device instance number by device switches or operator interface.
c. LAN is to support up to 4,194,302 unique devices.

4. Device Object Name Property Text:

a. Device object name property field to support 32 minimum printable characters.
b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.

1) Example 1: Device object name for heating hot water supply temperature would be "XPL_HW_HWS_TEMP."
2) Example 2: Device object name for VAV terminal unit controller served by AHU-1 would be "AH01_TEC_RM_101."

3.17 INSTALLATION OF CONTROL WIRE, CABLE, AND RACEWAY

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Comply with installation requirements in Division 26 specifications for Control-Voltage Electrical Power Cables.
2. Comply with installation requirements in Division 27 sections for Communications Copper Backbone Cabling.
3. Comply with installation requirements in Division 27 sections for communications Copper Horizontal Cabling.
4. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.

a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.

5. Terminate wiring in a junction box.

a. Clamp cable over jacket in a junction box.
b. Individual conductors in the stripped section of cable is to be slack between the clamping point and terminal block.

6. Terminate field wiring and cable not directly connected to instruments and control

devices having integral wiring terminals using terminal blocks.
7. Install signal transmission components in accordance with IEEE C2, REA Form 511a, NFPA 70, and as indicated.
8. Use shielded cable to transmitters.
9. Use shielded cable to temperature sensors.
10. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Division 26 sections for Raceway and Boxes for Electrical Systems for control-voltage conductors.
2. Comply with Division 27 sections for Pathways for Communications Systems, for balanced twisted pair cabling and optical fiber installation.

3.18 INSTALLATION OF OPTICAL FIBER CABLE SYSTEMS

A. Comply with installation requirements in Division 27 specifications for Communications Optical Fiber Backbone Cabling, and Communications Optical Fiber Horizontal Cabling.

3.19 FIELD QUALITY CONTROL

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

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

C. Perform the following tests and inspections[with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.20 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

E. Control Damper Checkout:

1. For pneumatic control dampers, verify that pressure gauges are provided in each air line connected to the damper actuator and positioner.
2. Verify that control dampers are installed correctly for flow direction.
3. Verify that proper blade alignment, either parallel or opposed, has been provided.
4. Verify that damper frame attachment is properly secured and sealed.
5. Verify that damper actuator and linkage attachment are secure.
6. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
7. Verify that damper blade travel is unobstructed.

F. Control Valve Checkout:

1. For pneumatic control valves, verify that pressure gauges are provided in each air line connected to the valve actuator and positioner.
2. Verify that control valves are installed correctly for flow direction.
3. Verify that valve body attachment is properly secured and sealed.
4. Verify that valve actuator and linkage attachment are secure.
5. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
6. Verify that valve ball, disc, or plug travel is unobstructed.
7. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace valve if leaks persist.

G. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction, and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type, and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments, verify the following:
   a. Sensing element type and proper material.
   b. Length and insertion.

3.21 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION, AND TESTING

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration to comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

1. Use field testing and diagnostic instruments and equipment with an accuracy at least twice the instrument accuracy of instrument to be calibrated. For example, test and calibrate an installed instrument with accuracy of 1 percent using field testing and diagnostic instrument with accuracy of 0.5 percent or better.

F. Calibrate each instrument in accordance with instruction manual supplied by instrument manufacturer.

G. If after calibration the indicated performance cannot be achieved, replace out-of-tolerance instruments.

H. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements, and to supplement requirements indicated.

I. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

J. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

K. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Check and document open and close cycle times for applications with cycle time less than 30 seconds.
3. For control dampers equipped with positive position indication, check feedback

signal at multiple positions to confirm proper position indication.

L. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Check and document open and close cycle times for applications with cycle time less than 30 seconds.
3. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Meters: Check meters at zero, 50, and 100 percent of Project design values.

N. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

O. Switches: Calibrate switches to make or break contact at set points indicated.

P. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.22 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase, and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.

B. Verify that wire and cabling are properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.23 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify that operation is stable and accurate.
4. Adjust control loop proportional, integral, and derivative settings to achieve

optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.

5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:
    a. Upper quarter of range.
    b. Lower quarter of range.
    c. At midpoint of range.
8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller, and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller, and at field instrument must match.
10. Prepare and submit report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.24 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests of entire BAS before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After review and approval of Pretest Checklist and Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed Pretest Checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

1. Detailed explanation for any items that are not completed or verified.
2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
3. Required DDC system components, wiring, and accessories are installed.
4. Installed DDC system architecture matches approved Drawings.
5. Control electric power circuits operate at proper voltage and are free from faults.
6. DDC system network communications function properly, including uploading and downloading programming changes.
7. Each controller's programming is backed up.
8. Equipment, products, tubing, wiring cable, and conduits are properly labeled.
9. All I/O points are programmed into controllers.
10. Testing, adjusting, and balancing work affecting controls is complete.
11. Dampers and actuators zero and span adjustments are set properly.
12. Each control damper and actuator goes to failed position on loss of power and loss of signal.

13. Valves and actuators zero and span adjustments are set properly.
14. Each control valve and actuator goes to failed position on loss of power and loss of signal.
15. Meter, sensor, and transmitter readings are accurate and calibrated.
16. Control loops are tuned for smooth and stable operation.
17. View trend data where applicable.
18. Each controller works properly in standalone mode.
19. Safety controls and devices function properly.
20. Interfaces with fire-alarm system function properly.
21. Electrical interlocks function properly.
22. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphics are created.
23. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit validation Test Plan including test procedures for performance validation tests.
2. Address all specified functions of DDC system and sequences of operation in Test Plan.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include Test Checklist to be used to check and initial that each test has been successfully completed.
6. Submit Test Plan documentation no later than 10 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.

   a. Verify analog I/O points at operating value.
   b. Make adjustments to out-of-tolerance I/O points.

      1) Identify I/O points for future reference.
      2) Simulate abnormal conditions to demonstrate proper function of safety devices.
      3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
5. After validation testing is complete, prepare and submit report indicating results of testing. For all I/O points that required correction, indicate how many validation

re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Response Time Test: Verify and demonstrate proper response times for connected I/O per paragraph 2.4,F

H. Third Party Operational Testing: The Owner is to engage, through the General Contractor, an independent commissioning service provider, who will generate a plan and List of Functional Tests for HVAC and Controls systems, some of which will include repeating validation of DDC systems and sequences of operation. The independent commissioning service provider will self-perform all tests; however, this contractor for Controls is to provide review of that Functional Tests List, with written comment, to be returned to the General Contractor (within 15 days of receipt).

3.25 FINAL REVIEW

A. Submit written request to Architect and Construction Manager when DDC system is ready for final review. State the following:
   1. DDC system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
   2. DDC system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
   3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
   4. DDC system is complete and ready for final review.
   5.

B. Upon receipt of written request for final review, Construction Manager to start review within 10 business days and upon completion issue field report(s) documenting observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in reviewer's field report(s) and submit second written request after all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Demonstrate operation of the DDC completed DDC system to Owner staff.
   1. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
   2. Demonstration to include, but not be limited to, the following:
      a. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 I/O points to be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
      b. Correct sequence of operation after electrical power interruption and

resumption after electrical power is restored for randomly selected HVAC systems.

c. Operation of randomly selected dampers and valves in normal-on, normal-off, and failed positions.
d. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
e. Trends, summaries, logs, and reports set up for Project.
f. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
g. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
h. Execution of digital and analog commands in graphic mode.
i. Online user guide and help functions.

3. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Requirements must be met even if only one manufacturer's equipment is installed.

1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.
2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.
3) Set-Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated. Modifications are made with messages and write services initiated by operator using workstation graphics, or by completing a field in menu with instructional text
4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.
5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.
6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.
7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.
8) Archival Storage of Data: Data archiving is handled by operator

workstation and server and local trend archiving and display is accomplished.

9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.
10) Device and Network Management:
    a) Display of network device status.
    b) Display of BACnet object information.
    c) Silencing devices transmitting erroneous data.
    d) Time synchronization.
    e) Remote device re-initialization.
    f) Backup and restore network device programming and master database(s).
    g) Configuration management of routers.

3.26 EXTENDED SUPPORT

A. Operate DDC system for operating period of 28 consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Owner.

B. Provide online remote monitoring of the project to review and identify any operational problems with software or hardware for a period of two months from the point of completed startup. Report findings to the construction manager.

C. Provide technical support personnel made available for same-day response during normal business hours for emergency service on the system during the warranty period upon request from the construction manager or owner.

D. Provide to the construction manager proposed additional hourly rate for any service necessary outside of business hours.

3.27 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of completed validation testing; provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.28 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at completed validation testing, verify that service agreement includes software support for two year(s).

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within one year(s) from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.

1. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.29 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.

C. Provide on-site training to Owner operating staff, up to 40 total hours: including, at minimum:

1. Project walk-through to locate control components
2. Explanation of system documents and manuals
3. Instruction on system access and navigation utilizing operator workstation and peripheral devices
4. Instruction on system operation through portable workstation and through web browser
5. Explain and demonstrate how to make adjustments, calibrations
6. Explanation of control functions through graphic interface and generating new graphics
7. Instructed on how to access and interpret trends, and how to create new trends
8. Instruction on response to alarms, how to address alarms
9. Explain how to create new schedules and sequences
10. Show how to make adjustments, calibrations.
11. Describe replacement procedures

D. Training Schedule:

1. Schedule training with Owner 20 business days before expected Substantial Completion.
2. Schedule training sessions to provide Owner with at least 10 business days of notice in advance of training sessions.
3. Training to occur within normal business hours at mutually agreed on time. Unless otherwise agreed to, training to occur Monday through Friday, except on U.S. Federal holidays.

E. Attendee Training Manuals:

1. Provide each attendee with color hard copy of all training materials and visual

presentations.

2. Organize hard-copy materials in three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes DVD or flash drive with PDF copy of all hard-copy materials, text searchable form.

END OF SECTION 230923

SECTION 230923.12 - CONTROL DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular control dampers with airfoil blades.
2. Electric and electronic control-damper actuators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of damper and actuator:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and[mounting] details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for pneumatic signal and main air tubing.

C. Delegated Design Submittals:

1. Schedule and design calculations for control dampers and actuators, including the following:

   a. Unique designation for each damper/actuator assembly.
   b. Service/application.
   c. Damper assembly size.
   d. Damper assembly weight, including actuator(s).
   e. Damper and actuator action (modulating or two position).
   f. Flow at project design and minimum flow conditions.
   g. Face velocity at project design and minimum airflow conditions.
   h. Pressure drop across damper at project design and minimum airflow

conditions.
i. AMCA 500D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
j. Maximum close-off pressure.
k. Leakage airflow at maximum system pressure differential (fan close-off pressure).
l. Damper torque required at worst-case condition for sizing actuator.
m. Actuator selection indicating torque provided.
n. Actuator fail-safe position on loss of power and loss of signal.
o. Remarks listing special requirements.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are indicated and coordinated with each other, using input from installers of the items involved:
1. Product installation location indicated in relationship to room, duct, and equipment.
2. Size and location of wall access panels for control dampers and actuators installed behind walls.
3. Size and location of ceiling access panels for control dampers and actuators installed above inaccessible ceilings.
4. Refer to Section 230500.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control dampers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE 62.1 Compliance: Applicable outdoor ventilation requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. Code Compliance: Comply with governing energy code.

E. Ground Fault: Properly ground products to prevent failing due to ground fault conditions.

F. Environmental Conditions: For actuators not available with integral enclosures complying with requirements indicated, house in protective secondary enclosures complying with requirements.

G. Selection Criteria:

1. Multi-Blade Damper Configuration: See Drawings:
    a. Two-Position Control: Opposed or parallel.
    b. Equipment Isolation Applications: Opposed or parallel.
    c. Outdoor/Return Air-Mixing Applications: Opposed.
    d. Modulating control: Opposed.
2. Pressure and Temperature: Control dampers suitable for operating conditions encountered by the application and following conditions unless otherwise indicated on Drawings:
    a. Up to 4” WC static pressure, air conditions from 0 degrees to 100 degrees F.
3. Fail-Safe Positions: As follows unless otherwise indicated on Drawings:
    a. Supply Air: open.
    b. Return Air: open.
    c. Outdoor Air: Close
    d. Exhaust Air: Close.
4. Select dampers with smooth and stable operation throughout full range of operation over varying pressures and temperatures encountered.
5. Sizing: See Drawings
    a. Modulating Dampers: Select damper size for a pressure drop of no more than .1 “ WC at design flow unless otherwise indicated.
    b. Two-Position Dampers: Full size of duct or equipment connection unless otherwise indicated.

2.2 RECTANGULAR CONTROL DAMPERS WITH AIRFOIL BLADES

A. General Requirements:

1. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
    a. Include multisection damper assemblies with intermediate reinforcing where required between individual sections being joined together. Construct reinforcing of same material (aluminum, galvanized steel, stainless steel) as damper frame.
2. Factory install actuator(s) as integral part of damper assembly. Coordinate, with damper manufacturer, field requirements for actuators, such as type, fail-safe

position, power supply, location, and mounting requirements.

B. Rectangular Control Dampers with Galvanized-Steel Airfoil Blades and Frames:

1. Source Limitations: Obtain rectangular control dampers, with galvanized-steel airfoil blades and frames, from single manufacturer.
2. AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance and air leakage.
3. Performance:
    a. Leakage:
        1) AMCA 511, Class 1, at 4 in. wg differential static pressure: Leakage not to exceed 8 cfm/sq. ft. against 4 in. wg differential static pressure when tested in accordance with AMCA 500D.
    b. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/180 of blade length.
4. Construction:
    a. Frame:
        1) Material: ASTM A653/A653M galvanized steel, minimum 0.06 inch thick.
        2) Arrangement: Hat-shaped channel with integral extended face flange(s) having mating face of minimum 1 inch for attachment to duct flanges, plenum walls, and equipment.
        3) Width: Not less than 5 inches.
    b. Blades:
        1) Configuration: Parallel or opposed blade configuration as required by application.
        2) Material: ASTM A653/A653M galvanized steel, 0.05 inch thick.
        3) Shape: Hollow, airfoil.
        4) Length: As required by close-off pressure rating, not to exceed 48 inches.
        5) Width: Not to exceed 6 inches.
    c. Seals:
        1) Blades: Replaceable; extruded silicone, vinyl, or damper manufacturer-offered equivalent, as required by performance requirements. Seals are to be mechanically attached in extruded blade slots.
        2) Jambs: Stainless steel, compression type.
    d. Axles:
        1) Diameter: Minimum 0.375 inch.
        2) Material: Plated steel.
        3) Mechanically attached to blades.

e. Bearings:

1) Material: Molded nylon or stainless steel sleeve, as required by operating conditions, mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Hardware: stainless steel.
2) Material: Plated steel or stainless steel.
3) Mounting: Concealed in frame.

g. Transitions with Sleeve:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connections.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.

a) Sleeve length not less than 12 inches for dampers without jackshafts and not less than 16 inches for dampers with jackshafts.
b) Oversize damper and sleeve for duct connection size plus minimum 4 inches.

3) Fabricate sleeve and transitions of galvanized steel.
4) Match end connections (flange or sleeve) to field connections.

2.3 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Coordinate with equipment manufacturers for dampers integral to their equipment, and provided as part of their equipment package.

B. Select actuators to operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

C. Select actuators with sufficient power and torque to close off against the maximum system pressures encountered. Actuators are to be sized to close off against the fan shutoff pressure as a minimum requirement.

D. The total damper area operated by an actuator is not to exceed 80 percent of manufacturer's maximum area rating.

E. Provide one actuator for each damper assembly where possible. Operate multiple actuators required to drive a single damper assembly in unison.

F. Avoid the use of excessively oversized actuators, which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

G. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

H. Provide mounting hardware and linkages for connecting actuator to damper.

I. Select actuators to fail-safe in desired position in the event of a power and signal failure.

2.4 ELECTRIC AND ELECTRONIC CONTROL-DAMPER ACTUATORS

A. Manufacturers: Subject to compliance with requirements, products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Belimo Aircontrols (USA), Inc
2. Honeywell Building Solutions; Honeywell International, Inc.
3. Johnson Controls, Inc.
4. Schneider Electric USA, Inc.
5. Siemens Industry, Inc., Building Technologies Division

B. Source Limitations: Obtain electric and electronic control-damper actuators from single manufacturer.

C. Type: Motor operated, with or without gears, electric and electronic.

D. Voltage:

1. Voltage selection is delegated to professional designing control system.
2. Actuator to deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
3. Actuator to function properly within a range of 85 to 120 percent of nameplate voltage.

E. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed-steel enclosures.
2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains are to be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

F. Local Field Adjustment: Make spring-return actuators easily switchable from fail-safe open to fail-safe closed in the field without replacement.

G. Local Manual Override: Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

H. Two-Position Actuators: Single direction, spring return or reversing type.

I. Modulating Actuators:

1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:
    a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
    b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for 0 to 10, or 2 to 10 V dc, and[4 to 20 mA signals.
    c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink, or source controller.
    d. Programmable Multifunction:
        1) Control input, position feedback, and running time are to be factory or field programmable.
        2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
        3) Service data, including at a minimum, number of hours powered and number of hours in motion.

J. Position Feedback:

1. two-position actuators with limit switches or other positive means of a position indication signal for remote monitoring of position.
2. modulating actuators with a position feedback through current or voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

K. Fail-Safe:

1. Where indicated, provide actuator to fail-safe to an end position.
2. Internal spring-return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other nonmechanical forms of fail-safe operation are acceptable only where uniquely indicated.

L. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.

2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

M. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and setscrew method of attachment is acceptable only if provided with at least two points of attachment.

N. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of [minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range is to be from 5 to 95 percent relative humidity, noncondensing.

O. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 for outdoor and unprotected applications.

P. Stroke Time:

1. Select operating stroke time to be compatible with equipment and system operation, and as follows.
   a. Operate damper from fully closed to fully open position within 15 seconds.
   b. Operate damper from fully open to fully closed position within 15 seconds.
   c. Move damper to fail-safe position within 15 seconds.
2. For actuators operating in smoke-control and other life-safety systems, comply with governing code and NFPA requirements.

Q. Sound: Where actuators are located in tenant-occupied rooms with a room sound-level criteria of NC-25 or lower, comply with the following sound levels:

1. Spring Return: 40 dBA.
2. Nonspring Return: 40 dBA.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 CONTROL-DAMPER APPLICATIONS

A. Coordinate with equipment manufacturers for dampers integral to their equipment, and provided as part of their equipment package

B. Select from damper types indicated to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

C. Rectangular Control Dampers with Insulated Blade Applications:

1. Exhaust Air: Rectangular dampers with insulated aluminum airfoil blades and thermal break frames within 10 feet of exterior opening to roof or perimeter wall.
2. Outdoor Air: Rectangular dampers with insulated aluminum airfoil blades and thermal break frames within 10 feet of exterior opening to roof or perimeter wall.
3. Return Air: Rectangular dampers with aluminum airfoil blades.
4. Supply Air: Rectangular dampers with airfoil blades.

D. Rectangular Control Dampers with Integral Airflow Applications:

1. Applications with Airflow Measurement: Rectangular dampers with aluminum airfoil blades and integral airflow measurement using pressure sensing.
2. Applications with Airflow Control: Rectangular dampers with aluminum airfoil blades and integral airflow control using pressure sensing.

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Coordinate with the Mechanical Contractor to have control damper installed by sheet metal and duct systems installed, under the guidance of the temperature controls contractor.

C. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic, wind, or others forces common to the application.

D. Provide ceiling, floor, roof, and wall openings[, and sleeves required by installation.

Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Seal penetrations made in fire-rated and acoustically rated assemblies.

F. Fastening Hardware:

1. Wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.4 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 30 degrees, to dampers larger or smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access unless more space is recommended by manufacturer. Provide code required clearances as applicable.

C. Service Access:

1. Install dampers and actuators to be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions.

E. Install supplementary structural reinforcement for large multiple-section dampers if factory-furnished support alone cannot handle loading.

F. Attach field-installed actuator(s) to damper drive shaft.

G. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with damper identification on damper[and on face of ceiling where damper is concealed above ceiling].

3.6 ELECTRICAL CONNECTIONS

A. Install electrical power to field-mounted control devices requiring electrical power.

B. Connect wiring in accordance with Division 26 specification sections for "Low-Voltage Electrical Power Conductors and Cables" and Section 260523 "Control-Voltage Electrical Power Cables."

C. Ground equipment in accordance with Division 26 specification sections for "Grounding and Bonding for Electrical Systems."

D. Furnish and install raceways. Comply with requirements in Division 26 specification sections for "Conduits for Electrical Systems."

E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Division 26 specification sections for "Identification for Electrical Systems."
2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.7 CONTROL CONNECTIONS

A. Install control signal wiring to field-mounted control devices.

B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

C. Furnish and install raceways. Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems."

3.8 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

3.9 STARTUP

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Verify that control dampers are installed correctly for flow direction.
4. Verify that proper blade alignment, either parallel or opposed, has been provided.
5. Verify that damper frame attachment is properly secured and sealed.
6. Verify that damper actuator and damper linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that damper blade travel is smooth and unobstructed throughout operating range.
9. ~~Pneumatic Control Dampers:~~
   a. ~~Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.~~
   b. ~~Verify air supply for each product is properly installed.~~
   c. ~~Verify that pressure gauges are provided in each air line to damper actuator and positioner.~~

3.10 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.12

SECTION 230923.14 - FLOW INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Airflow measurement stations and sensors.
2. Airflow transmitters.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Airflow measurement stations and sensors.
2. Airflow switches.
3. Airflow transmitters.
4. Liquid flow switches.

B. Product Data Submittals: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.
5. Product certificates.

C. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

D. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.
5. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

6. Refer to Section 230500 – “coordination drawings”

E. Delegated Design Submittal:

1. Schedule and design calculations for flow instruments, including the following.
    a. Flow at Project design and minimum flow conditions.
    b. Pressure drop at Project design and minimum flow conditions.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

B. Product Test Reports: Tests performed by a qualified testing agency.

1. Airflow measurement stations and sensors.
2. Airflow switches.
3. Airflow transmitters.
4. Liquid flow switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Select and size products to achieve specified performance requirements.

B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS

A. Air sensors and transmitters are to have an extended range of 20 percent above Project design flow and 20 percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

B. Source Limitations: For flow instruments, obtain products from single source from single manufacturer.

2.3 AIRFLOW MEASUREMENT STATIONS AND SENSORS

A. Performance Requirements:

1. Adjustable for changes in system operational parameters.
2. Airflow Sensor and Transmitter Range: Extended range of 20 percent above Project design flow and 20 percent below minimum Project flow to signal abnormal flow conditions.
3. Manufacturer is to certify that each flow instrument indicated complies with specified performance requirements and characteristics.
    a. Product certificates are required.

B. Thermal Airflow Measurement Stations:

1. Common Performance Requirements:
    a. Provide stations that are adjustable for changes in system operational parameters.
    b. Manufacturer is to certify that each flow instrument indicated complies with specified performance requirements and characteristics.
    c. Thermal airflow stations with one or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location.
    d. Sensor Nodes: One self-heated and one zero-power bead-in-glass thermistor, using the principle of thermal dispersion.
    e. Airflow Rate and Temperature of Each Sensor: Equally weighted and averaged by the transmitter prior to output.
    f. Sensor-Node and Probe Assemblies:
        1) Sensor-Node Construction: Two bead-in-glass, hermetically sealed thermistors potted in a marine-grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene. Construct with only the thermistor located within the sensing node and all other electronic components outside the airstream. Epoxy- or glass-encapsulated chip thermistors or devices with exposed leads are not allowed. Devices that use epoxy- or glass-encapsulated chip thermistors, or electronics in the airstream, are unacceptable. Devices with exposed leads are un acceptable.
        2) Sensing-Node Temperature Accuracy: Within 0.15 deg F over an operating range of minus 20 to plus 160 deg F and humidity range of 0 to 100 percent RH.
        3) Internal Probe Wiring: Kynar-coated copper between the connecting cable and sensor nodes. PVC-jacketed wiring is unacceptable.
        4) Sensor-Probe Jacket: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from minus 67 to plus 392 deg F, and for continuous and direct UV exposure. Plenum-rated PVC jacket cables are unacceptable.
    g. Transmitter Features and Functions:
        1) High and/or low airflow alarm with user-defined set point and percent of set-point tolerance.

2) Manual or automatic alarm reset, and low-limit cutoff value may be selected to disable the alarm.
3) Alarm delay function, field defined.
4) Sensor-node malfunction via the system status alarm and ignore the sensor node that is in a fault condition.
5) Field configuration, diagnostics, and field output adjustment wizard that allow for a one- or two-point field adjustment to factory calibration for installations that require adjustment.
6) Automatic reset after power disruption, transients, and brown-outs through a watchdog timer circuit.
7) Operating temperature range of minus 20 to plus 120 deg F and humidity range of 5 to 95 percent RH.
8) Electrical Power Requirement: 24 V ac (between 22.8 and 26.4 V ac under load) at 20 VA maximum, using a switching power supply that is overcurrent and overvoltage protected.
9) Printed Circuit Board Interconnects: Gold-plated edge fingers, receptacle plug pins, and printed circuit board test points.
10) Printed Circuit Boards: Electroless nickel immersion gold (ENIG) plated.
11) Integrated Circuitry: Temperature-rated, industrial-grade. Commercial-grade integrated circuitry is not acceptable.
12) Integration Buffers: Separate integration buffers for display of airflow output, airflow signal output (analog and network), and individual sensor output (IR-interface).

2. For Air-Ducted/Plenum:

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

1) Ebtron
2) Paragon Controls
3) Greenheck
4) Dwyer

b. Airflow Station Performance:

1) Independent processing of up to 16 separately wired sensor-node assemblies.
2) Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

c. Sensor-Node and Probe Assemblies:

1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory results.
2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.
   a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm.
   b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
3) Provide the number of independent sensor nodes as follows:
   a) For Duct/Plenum Area up to 0.5 sq. ft. (0.046 sq. m): One.
   b) For Duct/Plenum Area Greater Than 0.5 through 1.0 sq. ft. (0.046 through 0.092 sq. m): Two.
   c) For Duct/Plenum Area Greater Than 2.0 through 4.0 sq. ft. (0.186 through 0.372 sq. m): Six.
   d) For Duct/Plenum Area Greater Than 4.0 through 8.0 sq. ft. (0.372 through 0.743 sq. m): Eight.
4) For an aspect ratio of 1.5 or less, and an area of 25 sq. ft. or greater, four probes are required.
5) Sensor-Probe Construction: Gold-anodized, 6063 aluminum alloy tube or Type 316 stainless steel tube, with each sensor probe containing one or more independently wired sensing nodes.

d. Transmitter:
   1) Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.
   2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:
      a) Transmitter: Two field-selectable 0- to 5-V dc, 0-to 10-V dc, or 4- to 20-mA, scalable, isolated, overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.

3. For Packaged HVAC Units:
   a. Airflow Station Performance
      1) Independent processing of up to two separately wired sensor-node

assemblies.

2) Accuracy: Within 10 percent of reading when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

b. Sensor-Node and Probe Assemblies:

1) Sensor-Node Internal Wiring Connections: Sealed and protected from the elements and suitable for direct exposure to water. Devices with exposed leads are unacceptable.
2) Sensor-Node Calibration:

a) Individually calibrated at a minimum of seven calibration points to NIST-traceable airflow standards from 0 to 3000 fpm.
b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

3) Provide the number of independent sensor nodes as follows:

a) For a Duct Diameter of 4 Inches (102 mm): One.
b) For Duct Diameters 5 through 16 Inches (127 through 406 mm): Two.

4) Sensor-Probe Construction: Mill-finish, 6063 aluminum alloy tube, with each sensor probe containing one or more independently wired sensing nodes.

c. Transmitter:

1) Transmitter determines the average airflow rate and temperature of all connected sensor nodes in an array for a single location.
2) User Interface: An alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.
3) Model EF-A Transmitter, Analog Capability: Two field-selectable 0- to 5-V dc, 1- to 5-V dc, 0- to 10-V dc, or 2- to 10-V dc, scalable analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm.
4) Model EF-N Transmitter, Network Communications: RS-485 (BACnet MS/TP) network connection to provide average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.
5) Contact Closure Relay: One dry contact relay with onboard jumper to drive a remote LED, rated for no less than 30 V dc or 24 V ac at 3 A maximum. User configurable as normally open or normally closed

during set up.

2.4 AIRFLOW TRANSMITTERS

A. Pressure Differential Transmitters for Airflow Measurement:

1. Performance:

   a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
   b. Accuracy: Within 1 percent of the full-scale range.
   c. Hysteresis: Within 0.10 percent of full scale.
   d. Repeatability: Within 0.05 percent of full scale.
   e. Stability: Within one percent of span per year.
   f. Overpressure: 10 psig.
   g. Temperature Limits: Zero to 150 deg F.
   h. Compensate Temperature Limits: 40 to 150 deg F.
   i. Thermal Effects: 0.033 percent of full scale per degree F.
   j. Shock and vibration are not to harm the transmitter.

2. Output Signals:

   a. Analog Current Signal:

      1) Two-wire, 4- to 20-mA dc current source.
      2) Signal capable of operating into 800-ohm load.

   b. Analog Voltage Signal:

      1) Three wire, zero to 5, or 10 V.
      2) Minimum Load Resistance: 1000 ohms.

3. Display: Four-digit digital with minimum 0.4-inch- high numeric characters.
4. Operator Interface:

   a. Zero and span adjustments located behind cover.

5. Construction:

   a. Plastic casing with removable plastic cover.
   b. Fittings: Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.
   c. Screw terminal block for wire connections.
   d. Vertical plane mounting.
   e. NEMA 250, Type 4.
   f. Mounting Bracket: Appropriate for installation.

2.5 LIQUID FLOW METER

A. General Requirements for Liquid Flow Meters:

1. Adjustable for changes in system operational parameters.
2. Manufacturer is to certify that each flow instrument indicated complies with

specified performance requirements and characteristics.

B. Insertion Electromagnetic Flow Meter:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Onicon (model M3500)
   b. Honeywell
   c. Tek-Trol
   d. Omega
   e. FloTech
2. Description:
   a. No moving parts.
   b. Suitable for flow measurement of fluids with electrical conductivity between 20 to 60000 micro-Seimens per centimeter.
   c. Suitable for insertion in pipe size NPS 3.
   d. Wet calibrate and tag meters to standards traceable to NIST, and provide each meter with a certificate of calibration.
   e. Continuous auto-zero function.
   f. Transmitter integral to meter.
3. Performance:
   a. Flow Range: 0.25 to 20 fps.
   b. Accuracy for Velocities between 2 and 20 fps: Within 1 percent of reading.
   c. Accuracy for Velocities Less than 2 fps: Within 0.02 fps.
   d. Ambient Temperature: Minus 5 to 150 deg F.
   e. Process Temperature: 15 to 250 deg F.
   f. Pressure: 400 psig.
   g. Water flow pressure drop: less than .4 psig at design flow.
4. Output Signals:
   a. Field-selectable analog signals.
      1) Selectable Signal (Isolated): 4 to 20 mA.
      2) Selectable Signal (Isolated): Zero- to 5 Vdc or 0-10 V dc.
   b. Digital Signal: to communicate a fault condition.
   c. Frequency Signal: Zero- to 15-V peak pulse, zero to 500 Hz.
   d. Scalable Pulse Output:
      1) Isolated solid-state dry contact.
      2) Contact Rating: 100 mA at 50-V dc.
      3) Pulse Duration: 0.5, 1, 2, or 6 seconds.
5. Construction:
   a. Wetted Metal Parts: Type 316 stainless steel.
   b. Sensor Head: Vikon, EPDM, Polysulfone.
   c. Process Connection: 1 inch.

d. Instrument Isolation Valve: Full port Type 316 stainless steel full port ball valve for system isolation.
e. Electrodes: Type 316 stainless steel.
f. Electronics Enclosure:
   1) Painted aluminum.
   2) Removable cover.
   3) NEMA Type 4 aluminum.
   4) Electrical Connection: PVC-jacketed cable, 10 feet long.
   5) Conduit Connection: 1/2-inch trade size.

6. Display: none
7. Electrical:
   a. 20-28 VDC, 250 mA, 60Hz
   b. UL Listed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Provide the services of an independent inspection agency to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
   1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on shop drawings.
   2. Do not begin installation without submittal approval of mounting location.

E. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

F. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 INSTRUMENT APPLICATIONS

A. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

B. Thermal Airflow Measurement Stations:

1. For Air-Ducted/Plenum:
    a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.
    b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.
2. For Air-Ducted/Plenum - Duct Size 2 sq. ft. (0.18 sq. m) or Less:
    a. Measured Velocities Less Than 200 fpm (1.0 m/s): Thermal airflow measurement station.
    b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.
3. For Supply or Return Fan Array:
    a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.
    b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.
4. For Supply or Return Fan, Single-Width Single-Inlet (SWSI) or Double-Width Double-Inlet (DWDI) Fans:
    a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.
    b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.
5. For Packaged HVAC Units:
    a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.
    b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.
6. For Damper-Mounted Airflow Stations:
    a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.
    b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.

C. Duct-Mounted Airflow Sensors:

1. Measured Velocities 500 fpm (2.5 m/s) and Less: Thermal airflow station.
2. Measured Velocities Greater than 500 fpm (2.5 m/s): Pitot-tube airflow sensor

station, Thermal airflow station.

D. Damper-Mounted Airflow Sensors:

1. Measured Velocities 400 fpm (2.0 m/s) and Less: Thermal airflow station.
2. Measured Velocities Greater than 500 fpm (2.5 m/s): Pitot-tube airflow sensor station, Thermal airflow station.

E. Fan-Mounted Airflow Sensors:

1. Measured Velocities 500 fpm (2.5 m/s) and Less: Thermal airflow station.
2. Measured Velocities Greater than 500 fpm (2.5 m/s): Pitot-tube fan inlet airflow sensor station, Thermal airflow station.

F. Airflow Switches:

1. Measured Velocities 400 fpm (2.0 m/s) and Less: Polymer film sail switch.
2. Measured Velocities Greater than 400 fpm (2.0 m/s): Stainless steel single-vane switch.

G. Airflow Transmitters for Use with Pitot-Tube-Type Sensors:

1. Air Airflow: Airflow transmitter with 0.10 percent accuracy and auto-zero feature, Pressure differential transmitter for airflow measurement, switch and controller for airflow measurement.

H. Liquid Flow Switches:

1. Magnetic type.

I. Liquid Flow Transmitters:

1. Liquid pressure differential transmitter.

J. Refer to Section 230923, and 230993 for requirements, select features to communicate with BAS, and accomplish control intent.

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a <Insert value> force.

D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.4 ELECTRICAL CONNECTIONS

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.5 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Coordinate with equipment manufacturers for airflow stations integral to their equipment.
2. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
3. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
4. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
6. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height is to comply with codes and accessibility requirements.
2. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
   a. Make every effort to mount at 60 inches.

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.6 INSTALLATION OF FLOW INSTRUMENTS

A. Airflow Sensors:

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Installed sensors are to be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

B. Liquid Switches:

1. Install system process connection full size of switch connection, but not less than NPS 1. Install stainless steel bushing if required to mate switch to system connection.
2. Install switch in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
3. In applications where top-dead-center location is not possible due to field constraints, install switch at location along top half of pipe if switch is acceptable by manufacturer for mounting orientation.

C. Transmitters:

1. Install airflow transmitters serving an air system in a single location adjacent to or within system control panel.
2. Install liquid flow transmitters, not integral to sensors, in vicinity of sensor. Where multiple flow transmitters serving same system are located in same room, co-locate transmitters by system to provide service personnel a single and convenient location for inspection and service.

D. Liquid Flow Meters:

1. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Install pipe reducers for in-line meters smaller than line size. Install reducers at

distance from meter to avoid interference and impact on accuracy.

3. Install in-line meters with flanges or unions to provide drop-in and -out installation.
4. Insertion Meters:
    a. Install system process connections full size of meter connection, but not less than NPS 1. Provide stainless steel bushing if required to mate to system connection.
    b. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
    c. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing are to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Division 26 specification sections for Identification for Electrical Systems.

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.8 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.9 CHECKOUT PROCEDURES

A. Description:

1. Check out installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Flow Instrument Checkout:

1. Verify that sensors are installed correctly with respect to flow direction.

2. Verify that sensor attachment is properly secured and sealed.
3. Verify that processing tubing attachment is secure and isolation valves have been provided.
4. Inspect instrument tag against approved submittal.
5. Verify that recommended upstream and downstream distances have been maintained.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration are to meet instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments are to have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent is to be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

END OF SECTION 230923.14

SECTION 230923.23 - PRESSURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.
4. Liquid-pressure transmitters.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.
4. Liquid-pressure switches.
5. Liquid-pressure transmitters.

B. Product Data Submittals: For each product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Product installation location shown in relationship to room, duct, pipe, and equipment.
2. Wall-mounted instruments located in finished space, showing relationship to light switches, fire alarm devices, and other installed devices.
3. Size and location of wall access panels for instruments installed behind walls.
4. Size and location of ceiling access panels for instruments installed in accessible ceilings.
5. Refer to Section 230500, Coordination Drawings

B. Product Certificates: For each product requiring a certificate.

C. Product Test Reports: For each product requiring test performed by manufacturer and witnessed by a qualified testing agency.

D. Source quality-control reports.

E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments must operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
2. Instruments and accessories are to be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated ae to be housed in protective secondary enclosures. Instrument-installed location to dictate following NEMA 250 enclosure requirements:
   a. Outdoors, Protected: Type 2.
   b. Outdoors, Unprotected: Type 4.
   c. Indoors, Heated with Nonfiltered Ventilation: Type 2.
   d. Indoors, Heated and Air-Conditioned: Type 1.
   e. Mechanical Equipment Rooms:

1) Air-Moving Equipment Rooms: Type 1.

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:

1. Dwyer Instruments, Inc
2. Ashcroft
3. BAPI
4. Onicon (Air Monitor)
5. MAMAC Systems

2.3 AIR-PRESSURE SENSORS

A. Duct Insertion Static Pressure Sensor:

1. Insertion length to be at 4 inches.
2. Sensor with four radial holes of 0.04-inch diameter.
3. Brass construction.
4. Sensor with threaded end support, sealing washers and nuts.
5. Connection: NPS 1/4 compression fitting.
6. Suitable for flat oval, rectangular, and round duct configurations.

B. Outdoor Static Pressure Sensor:

1. Provides average outdoor pressure signal.
2. Sensor with no moving parts.
3. Kit includes sensor, vinyl tubing mounting hardware.

2.4 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch:

1. Diaphragm operated to actuate an SPDT snap switch.
   a. Fan safety shutdown applications: Switch with manual reset.
2. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
3. Enclosure Conduit Connection: Knock out or threaded connection.
4. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
5. High and Low Process Connections: Threaded, NPS 1/8.
6. Enclosure:
   a. Dry Indoor Installations: NEMA 250, Type 1.
   b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
   c. Hazardous Environments: Explosion proof.

7. Operating Data:

   a. Electrical Rating: 15 A at 120- to 480-V ac.
   b. Pressure Limits:

      1) Continuous: 45 inches wg.
      2) Surge: 10 psig.

   c. Temperature Limits: Minus 30 to 180 deg F.
   d. Operating Range: Approximately 2 times set point.
   e. Repeatability: Within 3 percent.
   f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.5 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:

1. Performance:

   a. Range: Approximately 2 times set point.
   b. Accuracy: Within 0.5 percent of the span at reference temperature of 70 deg F.
   c. Hysteresis: Within 0.02 percent of the span.
   d. Repeatability: Within 0.05 percent of the calibrated span.
   e. Stability: Within 0.25 percent of span per year.
   f. Overpressure: 15 psig.
   g. Temperature Limits: Minus 20 to 160 deg F.
   h. Compensate Temperature Limits: 35 to 135 deg F.
   i. Thermal Effects: 0.015 percent of full scale per degree F.
   j. Warm-up Time: Within 5 seconds.
   k. Response Time: 5 ms.
   l. Shock and vibration to not harm the transmitter.

2. Output Signals:

   a. Analog Current Signal:

      1) Two-wire, 4- to 20-mA dc current source.
      2) Signal capable of operating into 1000-ohm load.

   b. Analog Voltage Signal:

      1) Three wire, zero to 6 V.
      2) Minimum Load Resistance: 1000 ohms.

3. Operator Interface:

   a. Zero and span adjustments within 10 percent of full span.
   b. Potentiometer adjustments located on face of transmitter..

B. Air-Pressure Differential Transmitter with 0.25 Percent Accuracy and Auto Zero Feature:

1. Description:
   a. 4- to 20-mA dc output signal.
   b. NEMA 250, Type 1 enclosure.
   c. Construct assembly so shock, vibration, and pressure surges of up to 1 psig will neither harm nor affect the accuracy of the transmitter.
   d. Transmitter with automatic zeroing circuit capable of automatically readjusting the transmitter to zero at predetermined time intervals. The automatic zeroing circuit to re-zero transmitter to within 0.1 percent of true zero.
   e. Performance:
      1) Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
      2) Calibrated Span: Field adjustable, minus 40 percent of the range.
      3) Accuracy: Within 0.25 percent of natural span.
      4) Repeatability: Within 0.15 percent of calibrated span.
      5) Linearity: Within 0.2 percent of calibrated span.
      6) Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
   f. Integral digital display for continuous indication of pressure differential.

2.6 LIQUID-PRESSURE TRANSMITTERS

A. Liquid-Pressure Differential Transmitter with Field-Selectable Range:
1. Performance:
   a. Field-Selectable Ranges:
      1) 5, 10, 20 psig.
      2) 25, 50, 100 psig.
      3) 75, 150, 300 psig.
   b. Accuracy: Within 1 percent of the full-scale range.
   c. Static Pressure: 2 times full-scale range.
   d. Overpressure: Proof pressure 3 times full-scale range, burst pressure 5 times full scale.
   e. Compensate Temperature Limits: Zero to 180 deg F.
   f. Thermal Effects: 0.025 percent of full scale per degree F.
   g. Shock and vibration must not harm the transmitter.
2. Analog Output Current Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into 1000-ohm load.
3. Analog Output Voltage Signals:
   a. Three wire, field selectable from zero to 5 V or zero to 10 V.
   b. Minimum Load Resistance: 1000 ohms.

4. Operator Interface:
   a. Zero button located behind cover.
   b. Range selector located behind cover.
5. Provide transmitter with three-valve manifold.
   a. Construct manifold of Type 316 stainless steel.
   b. Manifold with threaded, NPS 1/4 process connections.

2.7 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled pressure instruments, as indicated by instrument requirements. Affix standards organization's certification and label.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 PRESSURE INSTRUMENT APPLICATIONS

A. Duct-Mounted Static Pressure Sensors:
   1. Duct insertion static pressure sensor.

B. Space Static Pressure Sensors:
   1. Space static pressure sensor for wall mounting, and space static pressure sensor for recessed ceiling mounting.

C. Air-Pressure Differential Switches:
   1. Air-pressure differential switch with set-point indicator, and air-pressure

differential switch with dual scale adjustable set point, air-pressure-differential indicating.

D. Air-Pressure Differential Transmitters:

1. Duct, Air-pressure differential transmitter with 0.25 percent accuracy and auto zero feature.
2. Space, Air-pressure differential transmitter with 0.25 percent accuracy and auto zero feature.

E. Liquid Gauge Pressure Switches:

1. Liquid gauge pressure switch, diaphragm operated, low pressure.

F. Liquid-Pressure Differential Switches:

1. Liquid-pressure differential switch with set-point indicator, liquid-pressure differential switch.

G. Liquid-Pressure Differential Transmitters:

1. Liquid-pressure differential transmitter with field-selectable range.

H. Refer to Section 230923, and 230993 for requirements, select features to communicate with BAS, and accomplish control intent.

3.3 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to force.

C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-

resistant coating that is suitable for environment.

4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRICAL CONNECTIONS

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Division 26 specification sections for Enclosed Switches and Circuit Breakers.

C. Furnish and install power wiring. Comply with requirements in Division 26 specification sections for "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Division 26 specification sections for "Conduits for Electrical Systems."

3.5 INSTALLATION OF PRESSURE INSTRUMENTS

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments (except pressure gauges) in liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
7. Install instruments in dry gas and noncondensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

C. Duct Pressure Sensors:

1. Install sensors using manufacturer's recommended upstream and downstream distances.
2. Unless indicated on Drawings, locate sensors approximately 75 percent of distance of longest hydraulic run. Location of sensors to be submitted and approved before installation.
3. Install mounting hardware and gaskets to make sensor installation airtight.
4. Route tubing from the sensor to transmitter.
5. Use compression fittings at terminations.
6. Install sensor in accordance with manufacturer's instructions.
7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.

D. Outdoor Pressure Sensors:

1. Install roof-mounted sensor in least-noticeable location and as far away from exterior walls as possible.
2. Locate wall-mounted sensor in an inconspicuous location.
3. Submit sensor location for approval before installation.
4. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
5. Route outdoor signal pipe full size of sensor connection to transmitters. Install branch connection of size required to match to transmitter.
6. Install sensor signal pipe with dirt leg and drain valve below roof penetration.
7. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
8. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.

E. Air-Pressure Differential Switches:

1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within 50 feet, otherwise, locate switch in vicinity of system connection.

F. Liquid-Pressure Differential Switches:

1. Where process connections are located in mechanical equipment room, install switch in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate switch near system control panel.
3.
4. Where multiple switches serving same system are installed in same room, install switches by system to provide service personnel a single and convenient location for inspection and service.
5. System process tubing connection to be full size of switch connection, but not less than NPS 1/2. Install stainless steel bushing if required to mate switch to system connection.
6. Connect process tubing from point of system connection and extend to switch.
7. Install isolation valves in process tubing as close to system connection as practical.
8. Install dirt leg and drain valve at each switch connection.
9. Do not mount switches on rotating equipment.
10. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
11. Install switches in an easily accessible location serviceable from floor.

G. Liquid-Pressure Transmitters:

1. Where process connections are installed in mechanical equipment room, install transmitter in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate transmitter near system control panel.
3. Unless indicated on Drawings, locate sensors approximately 75 percent of distance of longest hydraulic run to coils served. Minimum two for heating hot water (1st and second floor terminals submains). Location of sensors to be submitted and approved before installation.
4. Where multiple transmitters serving same system are installed in same room, install transmitters by system to provide service personnel a single and convenient location for inspection and service.
5. System process tubing connection to be full size of switch connection, but not less than NPS 1/2. Install stainless steel bushing if required to mate switch to system connection.
6. Connect process tubing from point of system connection and extend to transmitter.
7. Install isolation valves in process tubing as close to system connection as practical.
8. Install dirt leg and drain valve at each transmitter connection.
9. Do not mount transmitters on equipment.
10. Install in a location free from vibration, heat, moisture, or adverse effects, which

could damage and hinder accurate operation.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.7 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration to comply with instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments to have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent to be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of project design values.

3.9 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

END OF SECTION 230923.23

SECTION 230993.11 - SEQUENCE OF OPERATIONS FOR HVAC DDC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control sequences for DDC for HVAC systems, subsystems, and equipment.

B. Related Requirements:

1. Section 230923 "DDC Systems for HVAC" for control equipment.

1.2 DEFINITIONS

A. Analog Output: Proportional output signal (zero- to 10-V dc, 4 to 20 mA).

B. Binary Output: On/off output signal or contact closure.

C. DDC: Direct digital control (Building Automation System – BAS).

D. Digital Output: Data output that must be interpreted digitally.

E. OWS: Operator Work Station

F. T: Temperature

G. adj: Setpoint adjustable by operator directly

H. PID: Proportional Integral Derivative

I. ASHRAE 36: ASHRAE Guideline 36-2021, “High-Performance Sequences of Operation for HVAC Systems”, with Appendix C.

1.3 ACTION SUBMITTALS

A. Product Data:

1. An instrumentation list for each controlled system. Label each element of the controlled system in table format. Show, in the table element name, type of device, manufacturer, model number, and control device product data sheet number.
2. A complete description of the operation of the control system, including sequences of operation. Include and reference a schematic diagram of the controlled system.

B. Shop Drawings:

1. Proposed controls system architecture diagram, incorporating new and existing, in a relational structure.
2. Riser diagrams showing control network layout, communication protocol, and wire types.
3. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
4. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

1.4 HEATING HOT WATER CONTROL SEQUENCES

A. Gas-Fired Boilers: Two Existing Condensing Heating Hot Water Boilers

1. Input Device:
   a. Devices: Outdoor T, Supply Water T
   b. Transference: DDC controller.
2. Output Device:
   a. Device: DDC controller.
   b. Transference: Boiler manufacturer’s Integral controls.
3. Action:
   a. Enable existing boilers through DDC controller, outdoor temperature below 70 F (adj)
   b. Disable existing boilers through DDC controller at outdoor temperature above 70F (adj)
   c. Enable existing boilers through DDC to the lowest heating stage when outdoor T is above 70 only upon a heating call from air terminal. Disable existing boilers upon end of heating call from air terminal.
   d. When enabled, cycle existing boilers to maintain supply water T to building determined by a linear reset schedule using outdoor temperature, refer to ASHRAE 36 section 5.21:
      1) Outdoor T 10F (adj) or below – supply water T of 140 F (adj)
      2) Outdoor T 65F (adj) or above – supply water T of 100 F (adj)
   e. Existing boilers shall cycle, share operating hours, establish “lead/lag” assignments through existing integral boiler manufacturer’s controls.

B. Control Circulating Pump(s): Two Existing Boiler Primary, Constant Speed

1. Input Device:
   a. Device: start/stop point.
   b. Transference: Existing boilers controllers.
2. Output Device:
   a. Device: Command to electric relay.

b. Transference: Starter relay.

3. Action:

a. Existing boilers' primary pumps shall be enabled to operate through existing boiler manufacturer's integral controls.
b. Existing boiler primary pumps to be enabled whenever associated existing boiler is enabled, and disabled whenever associated existing boiler is disabled.

C. Building Circulating Pump(s): Two New Building Pumps, Two New VFDs

1. Input Devices:

a. Device: start/stop point, water pressure differential sensors (analog)
b. Transference: Existing boilers controllers, DDC controller.

2. Output Device:

a. Device: Command to relay, Analog output.
b. Transference: VFDs

3. Action:

a. New building pumps shall be enabled to operate through existing boiler manufacturer's integral controls.
b. New building pumps to be enabled whenever an existing boiler is enabled, and disabled whenever both existing boilers are disabled.
c. When enabled, building pump(s) shall maintain water pressure differential setpoint established through balancing (refer to Section 230539) by varying pump speed. Refer to ASHRAE 36 section 3.2.4.
d. Provide reverse acting PID, per ASHRAE 36 section 5.21.

D. Boiler Alarms:

1. Action:

a. Signal all alarm conditions from existing condensing boiler manufacturer's integral controls to OWS.

E. Circulating Pump(s) Failure Alarm:

1. Action:

a. Signal alarm condition, no pressure differential between supply and return piping.
b. VFD alarms

F. Alternate Pump(s):

1. Action: Operate pump(s) on lead-lag, alternating each startup.
2. Action: Operate pump(s) on lead-lag, alternating on 360 run hours (adj).

G. Indicate the following on the OWS:

1. DDC system graphic.
2. DDC system status, on-off.
3. Outdoor-air temperature.
4. Room temperatures.
5. Circulating pump(s) on-off status (enabled or disabled).
6. Circulating pump(s) on-off indication (operating or not operating).
7. Building circulating pump(s) pressure differentials.
8. Building circulating pump(s) pressure differential set points.
9. Building circulating pump(s) on-off indication (operating or not operating).
10. Circulating pump(s) alarm pressure differential.
11. Circulating pump(s) alarm pressure differential set point.
12. Alarm (circulating pump(s) failure).
13. Alarm (VFDs)
14. Building Circulating pump(s) speed
15. ~~Building Circulating pump(s) speed pressure differential setpoint.~~
16. Heating-water supply temperature to building.
17. Heating-water return temperature from building.
18. Heating-water entering and leaving temperatures at each existing boiler
19. Heating-water control-valve(s) positions.
20. Heating-water supply temperature set point.
21. Heating-water control-point output value.

1.5 CENTRAL CHILLED-WATER SYSTEM SEQUENCES

A. Central Chilled-Water System Time Schedule:

1. Occupied Time Schedule:
   a. Input:
      1) Device: DDC controller.
      2) Transference: DDC controller.
   b. Output:
      1) Device: DDC controller.
      2) Transference: chiller manufacturer’s integral controls
   c. Action:
      1) Enable startup, initiation, and control.
      2) Energize existing chiller and existing chilled water pumps on occupied/unoccupied cycle.
      3) Enable startup outside or occupied time schedule only upon cooling call, return to unoccupied time schedule when cooling call is satisfied.
      4) After chilled-water system shutdown, operate pump(s) for an additional 3 minutes (adj).
      5) Proof of flow, existing chiller flow switch
2. Display:

a. Time and time schedule.
b. Flow switch confirmed before chiller start

B. Start and Stop Two New Chilled-Water Pumps, Two New VFDs:

1. Input:
   a. Device: DDC controller.
   b. Transference: DDC controller.
2. Output:
   a. Device: Binary output.
   b. Transference: New VFDs.
3. Action: Energize pump(s) when the chiller system is enabled, disable pumps when existing chiller system is disabled (operate pump(s) for an additional 3 minutes (adj)).
4. Display:
   a. Chilled-water flow indication.
   b. Chilled-water pump(s) on-off status (enabled or disabled).
   c. Chilled-water pump(s) on-off indication (operating or not operating).
   d. Chilled water minimum flow setpoint
   e. Chilled-water actual flow
   f. Chiller(s) on-off status (enabled or disabled).
   g. Chiller(s) on-off indication (operating or not operating).
   h. Chilled-water supply and return temperature.
   i. Chilled-water temperature control set point

C. Alarm Chiller(s) Start Failure:

1. Input:
   a. Device: Software signal, Hardwired.
   b. Transference: DDC controller.
   c. Existing chiller integral controls
2. Output:
   a. Device: DDC controller.
   b. Transference: Operator's workstation.
3. Action: Signal alarm on signal from chiller control panel.
4. Display:
   a. Chiller "failure-to-start" indication.
   b. Chiller flow switch failure
   c. Flow rate below minimum setpoint
   d. Any alarms from existing chiller’s manufacturer’s integral controller.

D. Chilled-Water Supply Temperature:

1. Input:

a. Device: Liquid temperature sensor, with liquid temperature transmitter.
b. Transference: DDC controller.

2. Output:

a. Device: DDC controller signal.
b. Transference: OWS.

3. Action: Maintain chilled-water supply temperature.

a. Reset chilled-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

1) 44 deg F chilled water when outdoor-air temperature is 80 deg F or higher (adj).
2) 48 deg F chilled-water temperature when outdoor-air temperature is 60 deg F or lower (adj).

b. Reset chilled-water supply temperature based on maintaining a constant return chilled-water temperature of 56 deg F (adj).
c. Reset chilled-water supply temperature in response to greatest cooling demand to maintain at least one cooling control valve 90 percent open.
d. Utilize the lowest value result from multiple reset loops for the active chilled-water supply temperature.
e. Refer to ASHRAE 36 section 5.20.
f. Existing chiller will cycle compressors, condenser fans, utilizing the existing chiller manufacturer's integral controller.

4. Display:

a. Chilled-water supply temperature.
b. Active Chilled-water supply temperature set point.
c. Chilled water return temperature

E. Control Circulating Pump(s) Speed:

1. Input Device:

a. Device: Liquid pressure differential transmitter.
b. Transference: DDC controller.

2. Output Device:

a. Device: DDC controller.
b. Transference: New pump variable-speed controllers.

3. Action:

a. When enabled, existing chilled water building pump(s) shall maintain water pressure differential setpoint established through balancing (refer to Section 230539) by varying pump speed. Refer to ASHRAE 36 section 3.2.3.
b. Control pump speed to maintain flow through chiller (existing flow switch).
c. Control pump speed to establish minimum chilled water flow.
d. Report pressure drop and flow.

e. Report pressure drop and flow through chiller.

F. Minimum Chilled Water Flow

1. When pump(s) enabled, modulate bypass control valve between closed and minimum flow position established through balancing (refer to section 230539); per input from minimum flow meter
2. Report measured flow at minimum flow meter

G. Chiller Alarms:

1. Action:

a. Signal all alarm conditions from existing chiller manufacturer’s integral controls to OWS.

H. Circulating Pump(s) Failure Alarm:

1. Action:

a. Signal alarm condition, no pressure differential between supply and return piping.
b. Existing flow switch failure
c. Any VFD alarm

I. Alternate Pump(s):

1. Action: Operate pump(s) on lead-lag, alternating each startup.
2. Action: Operate pump(s) on lead-lag, alternating on 360 run hours (adj).

J. Indicate the following on the operator's workstation display terminal:

1. DDC system graphic.
2. DDC system status, on-off.
3. Outdoor temperature.
4. Cooling (software) demand indication.
5. Time and time schedule.
6. Chilled-water pump(s) on-off status (enabled or disabled).
7. Chilled-water pump(s) on-off indication (operating or not operating).
8. Chilled-water pump differential pressure setpoint
9. Chilled-water pump actual differential pressure
10. Chilled-water pump(s) speed.
11. Chilled-water control-valve(s) positions.
12. Chilled-water flow indication.
13. Chilled water minimum flow setpoint
14. Chilled water minimum flow valve position
15. Chilled water minimum flow meter rate
16. Refrigeration machine on-off indication (operating or not operating).
17. Chilled-water supply temperature.
18. Chilled-water return temperature.
19. Chilled-water temperature control-point adjustment.

20. Chiller(s) on-off status (enabled or disabled).
21. Chiller(s) on-off indication (operating or not operating).
22. Chiller "failure-to-start" indication.
23. Chiller(s) power input (instantaneous).
24. Chiller compressor(s) operating status, stages.
25. VFD alarms
26. System capacity in tons.

1.6 AIR-HANDLING-UNIT CONTROL SEQUENCES

A. Air-Handling Unit Time Schedule:

1. Occupied Time Schedule:

a. Input:

1) Device: DDC controller.
2) Transference: DDC controller.

b. Output:

1) Device: DDC controller.
2) Modulating hydronic control valves

c. Action:

1) Enable startup, initiation, and control.
2) Energize unit on occupied/unoccupied cycle.
3) Energize return/exh-air fans 30 seconds after supply fans are energized.
4) Do not enable mixed-air control during morning warm-up period.

a) Unoccupied: Position outdoor-air and relief-air dampers closed and return-air dampers open.

5) Enable control of heating coil(s) during morning warm-up period.
6) Return heating control valves to normal position when unit is cycled on.
7) Do not enable cooling-coil control during morning warm-up period.

B. Start and Stop Supply Fan(s):

1. Enable:

a. Input:

1) Device: Low limit temperature switch with automatic reset.
2) Location: Upstream of cooling coil.
3) Transference: Starter relay.

b. Output:

1) Device: Hard wired to motor controller and DDC controller.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Action:

1) Allow start if mixed air T is above 35 deg F (adj).
2) Signal alarm if fan fails to start as commanded.

2. Enable/Disable:

a. Input:

1) Device: Smoke detector with auxiliary contact manual reset.
2) Location: Mounted in air-handling unit.
3) Transference: Starter relay.

b. Output:

1) Device: Hard wired.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Output Device: Hard wired through motor controller; DDC controller alarm.
d. Action:

1) Allow start if airstream is free of detected smoke.
2) Disable if smoke detector senses smoke in airstream, stop all fans, issue alarm to DDC, Fire Alarm System (Refer to Division 28 specifications)
3) Signal alarm if fan fails to start as commanded.

C. Supply Fan(s) Variable-Volume Control:

1. Fan Speed Control:

a. Input:

1) Device: Air pressure transmitter.
2) Location: Supply-duct static pressure referenced to ambient-space static pressure.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Transference: Variable-frequency motor controller.

c. Action:

1) Maintain constant supply-duct static-pressure set point established through air balancing (refer to Section 230593). Refer to ASHRAE 36 section 3.2.
2) Set-Point Reset for Systems with DDC of Individual Zone Terminals: Reset static-pressure set point based on the zone requiring the most pressure; reset set point lower until one zone damper is nearly wide open.
3) Set variable-frequency drive to minimum speed when fan is stopped.
4) Provide following ASHRAE 36 Section 5.16

2. Fan Airflow:
   a. Input:
      1) Device: Airflow sensor, transmitter.
      2) Location: Supply duct.
      3) Transference: DDC controller.
   b. Output:
      1) Device: DDC controller.
   c. Action: Report supply-duct airflow.
3. Duct air pressure limits:
   a. Input:
      1) Device: Air pressure switch.
      2) Location: Supply duct, return duct, outdoor air duct, relief air duct.
      3) Transference: DDC controller.
   b. Output:
      1) Device: Binary output; DDC controller.
      2) Transference: Starter relay; operator's workstation.
   c. Action: When static pressure exceeds + or - static-pressure limit set point:
      1) Stop fans.
      2) Signal alarm.

D. Return/Exh Fan(s) Variable-Volume Control:
1. Fan Speed Control:
   a. Input:
      1) Device: Airflow sensor, transmitter.
      2) Transference: DDC controller.
   b. Output:
      1) Device: Analog output.
      2) Transference: Variable-frequency drive controller.
   c. Action:
      1) Maintain constant airflow offset between supply- and return-air fans.
      2) Set variable-frequency drive to minimum speed when fan is stopped.
2. Fan Speed Control:
   a. Input:
      1) Device: Air pressure sensor, differential transmitter.
      2) Transference: DDC controller.
   b. Output:
      1) Device: Analog output.

2) Transference: Variable-frequency motor controller.

c. Action:

1) Maintain constant indoor static-pressure set point of 0.02-inch wg (adj) positive.
2) Set variable-frequency drive to minimum speed when fan is stopped.

d. Action: Maintain constant indoor static pressure.

E. Hydronic Coils:

1. Freeze Protection:

a. Input:

1) Device: Air-temperature sensor RTD transmitter.
2) Location: After preheat coil.
3) Transference: DDC controller.

b. Output:

1) Device: Binary output, hard wired.
2) Transference: start.

c. Action: Stop fan and close outdoor air damper and relief air damper if temperature upstream of pre-heat coil is below 30 deg F (adj). Allow start if duct temperature is above 30 deg F (adj).

2. Supply-Air Temperature:

a. Input:

1) Device: Air-temperature sensor with air-temperature RTD transmitter.
2) Location: Discharge airstream past coils.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Transference: Control-valve actuators.

c. Action - cooling:

1) Maintain air-temperature set point of 55 deg F as cooling supply air T.
2) Provide trim-respond logic based upon outdoor air damper position, valve positions and terminal damper per ASHRAE 36 section 5.16.
3) Max cooling supply air temperature 62 deg F (adj)

d. Action – pre-heat:

1) Maintain air-temperature set point of 55 deg F as heating supply air T.
2) Provide trim-respond logic based upon outdoor air damper position, outdoor temperature and terminal damper positions per ASHRAE 36 section 5.16.

3) Max heating supply air temperature 70 deg F (adj)
4) During morning warm-up index heating supply air temperature to 75 deg F (adj)
5) Pre-heat disabled during cooling, dehumidification, economizer modes.

F. Mixed-Air Control:

1. Minimum Position:

a. Input:

1) Device: DDC controller.
2) Transference: DDC controller.

b. Input:

1) Device: Flow measuring station.
2) Location: Outdoor-air intake.
3) Transference: DDC controller.

c. Output:

1) Device: Analog output.
2) Transference: Damper actuator(s).

d. Action:

1) Open outdoor-air dampers to minimum position.
2) Modulate outdoor-air dampers and return dampers to maintain minimum airflow at set point required for minimum ventilation, set by air balancing (refer to schedules on drawings)
3) Refer to ASHRAE 36 section 3.2.
4) Provide logic per the ASHRAE 36 section 5.16

e. Outside air economizer

1) Provide calculation sequence for determining outdoor air enthalpy is below return air enthalpy, though limited to outdoor air drybulb temperature above 70 degrees F (adj) and a mixed air low limit temperature of 50 degrees F (adj).
2) Modulate return air damper, outdoor air damper, relief damper, relief fan speeds, in order to establish supply air temperature setpoint.
3) Operation of relief shall lag operation of return damper slightly.
4) Provide logic per ASHRAE 36 section 3.1 and 5.16

2. Setback:

a. Input:

1) Device: Time schedules, Space T, outdoor air T, DDC controller.
2) Transference: DDC controller.

b. Output:

1) Device: Binary output, Analog output.

2) Transference: Damper actuator(s), preheat coil valve, cooling coil valve

c. Action: Unoccupied setback

1) During unoccupied scheduled building hours, allow space setpoints to be relaxed by 5 degrees F.
2) Dampers for outdoor air intake, and relief, are to be closed (return dampers full open)
3) Utilize calculated cool-down for space to achieve occupied space T setpoints 30 minutes (adj) before scheduled occupied period start.
4) Utilize calculated morning warm-up to achieve occupied space T setpoint 30 minutes (adj) before scheduled occupied period start.
5) Provide calculation logic following ASHRAE 36 Section 5.4.

~~3. Carbon Dioxide Reset:~~

~~a. Input:~~

~~1) Device: Carbon dioxide transmitter.~~
~~2) Location: Space.~~
~~3) Transference: DDC controller.~~

~~b. Output:~~

~~1) Device: Analog output.~~
~~2) Location: Dampers.~~
~~3) Transference: Damper actuator(s).~~

~~c. Action: Reset minimum outdoor-air damper position to maintain carbon dioxide set point of 800 (adj). Refer to ASHRAE 36 section 3.1.~~
~~d. Provide control logic to group zones for CO2 control for each air handling unit per ASHRAE 36 section 5.2~~

4. Humidity Limit:

a. Input:

1) Device: Moisture sensor and transmitter.
2) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Transference: cooling valve, air terminal heating coil valves, air terminal dampers.

c. Action:

1) Return air RH above setpoint during cooling mode, 60% RH (adj)
2) Air Handling unit is providing minimum outdoor air for ventilation.
3) Index air handling unit supply air temperature setpoint to cooling supply T of 55 degrees F.
4) Index associated air terminals for the air handler to 80% (adj) of full cooling primary damper position.

5) Return air handler supply air temperature and associated air terminal units damper positions to previous status once return air RH limit is satisfied (2% RH below limit, adj)

6) Reheat coils at associated terminal units will modulate open, as needed, independently, to maintain zone space temperature setpoint.

a) Signal high humidity alarm.
b) Record Humidity Limit mode (date/time(s), air handling unit)
c) Record terminal units utilizing reheat

G. Filters:

1. Differential Pressure:

a. Action: Signal alarm on high-pressure conditions.

H. Coordination of Air-Handling Unit Sequences: Ensure that preheat, mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.

I. Indicate the following on the operator's workstation display terminal:

1. DDC system graphic.
2. DDC system on-off indication (operating or not operating).
3. DDC system occupied/unoccupied mode.
4. Outdoor-air-temperature indication.
5. Supply-fan on-off indication (operating or not operating).
6. Supply duct static-pressure indication.
7. Supply duct static-pressure set point.
8. Supply-fan airflow rate.
9. Supply-fan speed.
10. Return/Exh-fan on-off indication (operating or not operating).
11. Space static-pressure indication.
12. Space static-pressure set point.
13. Return/Exh-fan airflow rate.
14. Return/Exh-fan speed.
15. Preheat-coil air-temperature indication.
16. Preheat-coil air-temperature set point.
17. Preheat-coil control-valve position.
18. Mixed-air-temperature indication.
19. Mixed-air-temperature set point.
20. Mixed-air damper position.
21. Relative humidity indication.
22. Relative humidity set point.
23. Filter air-pressure-drop indication.
24. Filter low-air-pressure drop set point.
25. Filter high-air-pressure drop set point.
26. Supply-air-temperature indication.
27. Supply-air-temperature set point.

28. Heating-coil leaving-air-temperature indication.
29. Heating-coil leaving-air-temperature set point.
30. Heating-coil pump on-off indication (operating or not operating).
31. Heating-coil control-valve position.
32. Cooling-coil leaving-air-temperature indication.
33. Cooling-coil leaving-air-temperature set point.
34. Cooling-coil control-valve position.
35. Space temperature indication.
36. Space temperature set point.

1.7 SPACE HEATING UNITS OPERATING SEQUENCE

A. Cabinet Heater, Hydronic:

1. Space Temperature sensor:

a. Input:

1) Device: space sensor.
2) Maintain space temperature setpoint of 68 F (adj)

2. Action: heating call

1) Enable unit fan
2) Open hot water heating coil valve
3) When heating call is satisfied (2 degrees over setpoint), close heating coil valve, disable fan.

B. Unit Heater, Hydronic:

1. Space Temperature sensor:

a. Input:

1) Device: space sensor.
2) Maintain space temperature setpoint of 60 F (adj)

2. Action: heating call

1) Enable unit fan
2) Open hot water heating coil valve
3) When heating call is satisfied (2 degrees over setpoint), close heating coil valve, disable fan.

C. Radiant Heating Panel, Electric:

1. Space Temperature:

a. Input:

1) Device: Electronic thermostat.
2) Location: Space.

b. Output:

1) Device: Low-voltage wiring.
2) Location: Junction box.
3) Transference: Line-voltage relay.

c. Action: Cycle power to maintain the following space temperature set points:

1) Occupied: 72 deg F (adj)
2) Unoccupied building period: disabled.

1.8 SPACE TEMPERATURE MONITORING

A. Temperature:

1. Input: space T sensor, analog
2. Location: IN the following spaces:

a. IT server room
b. Elevator machine room
c. Garage

3. Transference: DDC controller.
4. Output:

a. Device: DDC controller.

5. Action: Record individual space temperatures. Alarm for individual high space temperature limit (95 degrees, adj) and alarm for individual low temperature limit (50 degrees F, adj).

1.9 VARIABLE-AIR VOLUME TERMINAL AIR UNITS, HYDRONIC REHEAT:

1. Space Temperature:

a. Input:

1) Device: Air-temperature-RH sensor, transmitter.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Control damper and valve actuators.
3) Input Transference: Control damper and valves.

c. Action: Modulate damper and valve to maintain the following space temperature set points:

1) Occupied Cooling Temperature: 75 deg F (adj).
2) Occupied Heating Temperature: 70 deg F (adj)
3) Unoccupied Cooling Temperature: 85 deg F (adj)
4) Unoccupied Heating Temperature: 65 deg F (adj).

d. Re-heat for space

1) Modulate primary damper actuator to minimum position.

2) When damper is at minimum position, modulate reheat coil valve from closed to open on heating call, maintain leaving air temperature setpoint (85 deg F, adj).
3) If occupied space temperature is not maintained after set time (10 minutes, adj), modulate damper actuator from minimum position to heating position. Modulate reheat coil valve open on continued heating call.
4) If occupied space temperature is not maintained after set time (10 minutes, adj), modulate damper actuator from heating position to full air flow position. Modulate reheat coil valve open on continued heating call.
5) Reverse the sequence for satisfied space temperature.

e. Cooling for space

1) Modulate primary damper actuator to minimum position.
2) When damper is at minimum position, if a call for cooling occurs, modulate primary air damper to open to full open position.
3) Upon space setpoint being satisfied (less .5 degree F), modulate primary air damper back toward minimum position.

2. For Terminals with integral series fan:

a. Re-heat for space

1) Modulate primary damper actuator to minimum position.
2) Fan will be enabled and run constantly during occupied time periods, operating at a constant speed set during the air balancing process.
3) Fans will cycle on only when called for heat or cooling during unoccupied scheduled time periods.
4) When damper is at minimum position, modulate reheat coil valve from closed to open on heating call, maintain leaving air temperature setpoint (85 deg F, adj).
5) If occupied space temperature is not maintained after set time (10 minutes, adj), modulate damper to the heating position. Modulate reheat coil valve open on continued heating call.
6) If occupied space temperature is not maintained after set time (15 minutes, adj), issue alarm to OWS.
7) Reverse the sequence for satisfied space temperature.

b. Cooling for space

1) Modulate primary damper actuator to minimum position.
2) Fan will be enabled during occupied time periods, operating at a constant speed set during the air balancing process.
3) When damper is at minimum position, if a call for cooling occurs, modulate primary air damper to open to full open position.
4) Upon space setpoint being satisfied (less .5 degree F), modulate primary air damper back toward minimum position.

3. Space RH:

a. Input

1) Space RH sensor

b. Output

1) Analog output
2) Air Terminal damper, reheat col valve

c. Action

1) Space RH is above setpoint (60% RH, adj)
2) Index associated air terminal primary damper to 100% (adj) open cooling position.
3) Reheat coil control valve modulate to open to maintain space temperature setpoint independently.
4) Issue alarm to OWS if space RH is not met after 15 minutes (adj)
5) Record action, date and time

4. During unoccupied scheduled building hours, space setpoints will be relaxed. Air Terminals will perform the following sequences as part of associated air handler morning cooldown and morning warm-up modes:

a. Index terminals primary air flow dampers to full flow position, for either morning cooldown or morning warm-up modes.
b. For morning warm-up, modulate reheat coil control valve to maintain supply air temperature setpoint.
c. Utilize calculated cool-down for space to achieve occupied space T setpoints 15 minutes (adj) before scheduled occupied period start.
d. Utilize calculated morning warm-up to achieve occupied space T setpoint 30 minutes (adj) before scheduled occupied period start.
e. Provide calculation logic following ASHRAE 36 Section 5.4

5. Indicate the following on the operator's workstation display terminal:

a. DDC system graphic.
b. DDC system on-off indication (operating or not operating).
c. DDC system occupied/unoccupied mode.
d. Outdoor-air-temperature indication.
e. Cabinet Unit Heater, Hydronic:

1) Space temperature indication.
2) Space temperature set point.
3) Fan on.

f. Unit Heater, Hydronic:

1) Space temperature indication.
2) Space temperature set point.
3) Fan on.

g. Radiant Heating Panel, Hydronic:

1) Space temperature indication.
2) Space temperature set point.

3) Control-valve position.

h. Variable-Air-Volume Terminal Air Units with Hydronic Coils:

1) Space/area served.
2) Space occupied/unoccupied.
3) Space temperature indication.
4) Space temperature set point.
5) Supply air temperature setpoint
6) Actual supply air temperature
7) Primary air flow (cfm)
8) Terminal fan failure (alarm)
9) Space cooling and heating temperature set point, occupied.
10) Space cooling and heating temperature set point, unoccupied.
11) Air-dampers positions as percentage open.
12) Control-valves positions as percentage open.
13) Space temperature and RH alarms

1.10 VENTILATION SEQUENCES

A. Exhaust Fan: scheduled occupancy.

1. Input:

   a. Device: DDC.

2. Output:

   a. Location: Motor controller.
   b. Transference: Starter relay.

3. Action: Enable fan on when space is occupied. Fan to be off when building is unoccupied.
4. Provide independent schedules for each exhaust fan. Exhaust fans serving rooms with mop basins will need to have an extended on/occupied period.

1.11 REPORTS, LOGS, TRENDS

A. Customizing programming

1. Provide programming to generate regular reports, logs and trending specific to the project’s systems, as defined in 230923, 2.10, F.
2. Demonstrate reporting, logs and trending to Owner.

PART 2 - PRODUCTS (Not Applicable)
PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230993.11

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Close-coupled, end-suction centrifugal pumps.
2. Separately coupled, base-mounted, end-suction centrifugal pumps.

1.2 DEFINITIONS

A. ECM: Electronically commutated motor.

B. EPDM: Ethylene propylene diene monomer.

C. EPR: Ethylene propylene rubber.

D. FKM: Fluoroelastomer polymer.

E. HI: Hydraulic Institute.

F. NBR: Nitrile rubber or Buna-N.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of pump.

1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
2. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For each pump.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.

   a. Design Calculations: Calculate requirements for selecting vibration isolators[and seismic restraints] and for designing vibration isolation bases.

b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates for pumps, 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.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in emergency, operation, and 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. Mechanical Seals: [One] <Insert number> mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[and seismic restraints].

C. Seismic Performance: Pumps shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified
2. Component Importance Factor: 1.0.

2.2 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:

1. Bell & Gossett (Xylem)
2. Armstrong Fluid Technology
3. Grundfos Pumps Corporation
4. Peerless Pump Company
5. Taco Comfort Solutions

B. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

D. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, formed foot-mount, threaded gauge tappings at inlet and outlet, and flanged connections.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft Sleeve: Type 304 stainless steel.
4. Pump Stub Shaft: Type 304 stainless steel.
5. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and EPDM bellows and gasket. Include water slinger on shaft between motor and seal.

E. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: drip-proof premium efficiency, support bracket.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Inverter duty motor with grounding for protection of bearings, intended for use with variable frequency speed drives.

F. Capacities and Characteristics:

1. Capacity: refer to schedules on plans
2. Electrical Characteristics:

a. Volts: 208 V.
b. Phase: Three.
c. Hertz: 60 Hz.

2.3 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:

1. Bell & Gossett (Xylem)
2. Armstrong Fluid Technology
3. Grundfos Pumps Corporation
4. Peerless Pump Company
5. Taco Comfort Solutions

B. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump with flexible shaft coupling as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

D. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gauge tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections. Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring realignment of pump and motor shaft.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Type 304 stainless steel.
4. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and EPDM bellows and gasket.
5. Seal, Packing Type: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

E. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor, EPDM coupling sleeve for variable-speed applications.

F. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

G. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A36/A36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

H. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: drip-proof premium efficiency.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Inverter duty motor with grounding for protection of bearings, intended for use with variable frequency speed drives.
6. Capacities and Characteristics:
7. Capacity: refer to schedules on plans

I. Electrical Characteristics:

1. Volts: 208 V.
2. Phase: Three.
3. Hertz: 60 Hz.

2.4 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting.
3. Bronze 16-mesh wire startup and type 304 stainless steel permanent strainers with 3/16-inch.
4. Type 304 stainless steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps will be installed.

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

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Equipment Mounting:

1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations, refer to Division 3 specifications.
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment service.

B. Perform alignment service. When required by manufacturer to maintain warranty coverage, engage a factory-authorized service representative to perform it.

C. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

D. Comply with pump and coupling manufacturers' written instructions.

E. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 PIPING CONNECTIONS

A. Where installing piping adjacent to pump, allow space for service and maintenance.

B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

D. Install suction diffuser and shutoff valve on suction side of pumps.

1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.

E. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

F. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

G. Install check valve on each condensate pump unit discharge unless unit has a factory-installed check valve.

3.5 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Division 26 specifications for "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Division 26 specifications for "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Division 26 specifications for "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Division 26 specifications for "Control-Voltage Electrical Power Cables."

C. Refer to section 230923 and 230993 for controls, communication and sequences.

D. Refer to section 232923 for variable frequency drives

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to assist in startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping. Use startup strainer for initial startup.
4. Perform the following startup checks for each pump before starting:
    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in correct direction.
5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to assist in test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Hydronic pumps will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to assist in training of Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 232123

SECTION 232500 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following HVAC water-treatment systems:

1. Manual and automatic chemical-feed equipment and controls.
2. Chemical-treatment test equipment.
3. Chemicals.

1.2 DEFINITIONS

A. EEPROM: Electrically erasable, programmable read-only memory.

B. PPM: Parts per million.

C. TDS: Total dissolved solids consist of salts and other materials that combine with water as a solution.

D. TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

1. Bypass feeders.
2. TDS controllers.
3. TSS controllers.
4. Chemical solution tanks.
5. Injection pumps.
6. Chemical test equipment.
7. Chemical material safety data sheets.
8. Inhibited propylene glycol.
9. Multimedia filters.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For chemical-treatment and equipment 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.

B. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

C. Field quality-control reports.

D. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.

E. Water Analysis: Illustrate water quality available at Project site.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sensors, injection pumps, water-filtration and controllers to include in operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 HVAC WATER-TREATMENT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:

1. Aqua-Chem, Inc.
2. Barclay Water Management, Inc
3. Earthwise Environmental Inc
4. Nalco; an Ecolab company
5. Chardon Labs
6. Watcon, Inc

2.2 PERFORMANCE REQUIREMENTS

A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems as indicated in this Specification. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or to the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including hot-water heating, chilled water with mix of water and propylene glycol; shall be brought within appropriate industry standards, and as required by equipment manufacturers served by the systems, for the following qualities:

1. pH: 6.5 – 9.5
2. Alkalinity: per manufacturer recommendations
3. Steel Corrosion Inhibiters: Provide sufficient inhibitors to limit mild steel corrosion. Maintain soluble iron concentrations at or below limits.
4. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion. Maintain soluble copper concentrations at or below limits.
5. Scale Control: Provide softened water for initial fill and makeup. Where softened water is not used, provide sufficient scale inhibitors to prevent formation of scale and maintain all scale-forming material in solution.
6. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate matter.
7. Microbiological Limits:
    a. Total Aerobic Plate Count: Maintain value of organisms below limits.
    b. Total Anaerobic Plate Count: Maintain value of organisms below limits.
    c. Nitrate Reducers: Maintain a value of organisms below limits.
    d. Sulfate Reducers: Maintain a value of organisms below limits.
    e. Iron Bacteria: Maintain a value of organisms below limits.
    f. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion.
    g. Maintain soluble copper concentrations at or below <Insert value> mg/L.
    h. Ammonia: Maintain a value below required limits.
    i. Dissolved Solids under 2,000 ppm

2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Inhibitor Injection Timers:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Programmable timers with infinite adjustment over full range, mounted in cabinet

with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. Digital display makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.

B. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: 50 gal..

C. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230500"
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints, except ASTM A269/A269M, Type 304 stainless steel for steam boiler injection assemblies.

E. Injection Assembly:

1. Quill: Minimum NPS 1/2 with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Two-piece stainless steel, as described in "Stainless Steel Pipes and Fittings" Article; selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig at 200 deg F.

2.4 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

B. Chemicals for direct steam injection humidification and for steam used in direct contact with food to be FDA approved and safe for these uses.

2.5 INHIBITED PROPYLENE GLYCOL

A. Inhibited Propylene Glycol:

1. Propylene glycol with inhibitor additive, to provide freeze protection for heat-transfer fluid and corrosion protection for carbon-steel, brass, copper, stainless steel, and cast-iron piping and fittings.
2. Inhibitor creates a passive layer on all surfaces that contact propylene glycol to prevent corrosion and stabilizes fluid pH, to compensate for acids formed from glycol degradation.
3. Operating Temperature Range: minus 50 deg F to 250 deg F
4. Concentrated inhibited propylene glycol is to be 95.5 percent propylene glycol by weight and 4.5 percent performance additives.
5. Concentrated inhibited propylene glycol is mixed with water in proper proportion specified by the manufacturer to provide freeze protection to minus 20 deg F (approximately 30%). Premixed heat-transfer fluid may be used, or glycol/water mixture may be prepared at the time of installation. Use only deionized water for mixing.
6. Provide only propylene glycol that is specifically blended for HVAC application. Automotive-type antifreeze is unacceptable.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

B. Perform an analysis of existing heating hot water and chilled water in the existing closed loops to determine present conditions. Report findings to construction manager.

3.2 CLEANING

A. Perform cleaning and flushing of existing system piping and equipment to remain to prepare the system for connection of new equipment and distribution piping.

1. Select detergents and rinse agents specifically for the systems, based upon findings from the initial water analysis.
2. The system shall be cleaned with detergent per manufacturer’s recommendation, rinsed. Allow detergents to remain in system as needed for effective cleaning. Flush to clear.
3. Repeat cleaning and flush again. Flush to clear.

3.3 INSTALLATION

A. Install chemical-application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate. Install all chemical application equipment within a spill-containment area without floor drains.

B. Install water-testing equipment on wall near water-chemical-application equipment.

C. Install interconnecting control wiring for chemical-treatment controls and sensors.

D. Mount sensors and injectors in piping circuits.

E. Install automatic fluid make-up equipment for glycol water system and include the following:

1. Chemical solution tanks.
2. Chemical solution injection pumps.
3. Water meter in makeup supply to system.
4. Pressure switch to operate injection pump as necessary to maintain glycol system pressure.

3.4 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 232113 "Hydronic Piping."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

3.5 ELECTRICAL CONNECTIONS

A. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

B. Ground equipment in accordance with Division 26 specifications for "Grounding and

Bonding for Electrical Systems."

C. Connect wiring in accordance with Division 26 specifications for "Low-Voltage Electrical Power Conductors and Cables."

3.6 FIELD QUALITY CONTROL

A. Testing Agency:

1. Owner will engage a qualified testing agency to perform tests and inspections.
2. Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation, and calibrate controls during the preliminary phase of HVAC system's startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials, and retest piping until no leaks exist.

E. Equipment will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Comply with ASTM D3370 and with the following standards:

1. Silica: ASTM D859.
2. Steam System: ASTM D1066.
3. Acidity and Alkalinity: ASTM D1067.
4. Iron: ASTM D1068.
5. Water Hardness: ASTM D1126.

3.7 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion, scale formation, and biological growth for chilled-water piping and heating, hot-water piping and associated equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to assist in training Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment. When training is complete, turn over video to Owner for future use.

END OF SECTION 232500

SECTION 232923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.2 DEFINITIONS

A. CE: (European Compliance).

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. LED: Light-emitting diode.

F. NC: Normally closed.

G. NO: Normally open.

H. OCPD: Overcurrent protective device.

I. PID: Control action, proportional plus integral plus derivative.

J. RFI: Radio-frequency interference.

K. VFC: Variable-frequency motor controller.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

1. Include dimensions and finishes for VFCs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.

1. Include mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and

size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Required working clearances and required area above and around VFCs.
2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
3. Show support locations, type of support, and weight on each support.
4. Indicate field measurements.
5. Refer to Section 230500 for Coordination Drawings

B. Qualification Data: For testing agency.

C. Seismic Qualification Data: Certificates, for each VFC, accessories, and components, from manufacturer.

1. Certificate of compliance.
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.

D. Product Certificates: For each VFC from manufacturer.

E. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

F. Source quality-control reports.

G. Field quality-control reports.

H. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 1 specification sections for Operation and Maintenance Data, include the following:

a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.

b. Manufacturer's written instructions for setting field-adjustable overload relays.
c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in heated and cooled space indoors, inside original manufacturer packaging, prevent damage and maintain units clean, until installed.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

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

PART 2 - PRODUCTS

2.1 VARIABLE-FREQUENCY MOTOR CONTROLLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. ABB, Electrification Business
2. Eaton

3. Nidec Motor Corporation; Nidec Corporation
4. Schneider Electric USA, Inc.
5. Siemens Industry, Inc., Building Technologies Division
6. Yaskawa Electric America, Inc.

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A, UL 61800 standard.

B. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

C. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

D. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

E. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.

6. Minimum Short-Circuit Current (Withstand) Rating: 100 kA.
7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
8. Humidity Rating: Less than 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet.
10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.35 times the base load current for two seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 5 percent.
14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

F. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

G. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

H. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

I. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, coordinated AC transient type, 4 MOVs, capacitor clamp and internal chokes
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor-overtemperature fault.

J. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

K. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

L. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

M. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

N. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

O. Integral Input Disconnecting Means and OCPD: UL 489, instantaneous-trip, molded-case switch, with power fuse block and current-limiting fuses, pad-lockable disconnect with door-handle mechanism.

1. Disconnect Rating: Not less than 115 percent of VFC input current rating.
2. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
4. NC alarm contact that operates only when circuit breaker has tripped.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFCs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[and the unit will be fully operational after the seismic event]."

2.4 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.

5. Overcurrent.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

a. A minimum of two programmable analog inputs: 0- to 10-V dc, 4- to 20-mA dc (operator-selectable),
b. A minimum of six multifunction programmable digital inputs.

2. Remote input signal, through digital input, to start and stop controlled equipment with remote low voltage toggle switch installed inn occupied space, powered

from VFD control circuit.

3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:
    a. 0- to 10-V dc.
    b. 4- to 20-mA dc.
    c. Potentiometer using up/down digital inputs.
    d. Fixed frequencies using digital inputs.
4. Output Signal Interface: A minimum of two programmable analog output signal(s) 0- to 10-V dc, 4- to 20-mA dc (operator-selectable) which can be configured for any of the following:
    a. Output frequency (Hz).
    b. Output current (load).
    c. DC-link voltage (V dc).
    d. Motor torque (percent).
    e. Motor speed (rpm).
    f. Set point frequency (Hz).
5. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
    a. Motor running.
    b. Set point speed reached.
    c. Fault and warning indication (overtemperature or overcurrent).
    d. PID high- or low-speed limits reached.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

1. Number of Loops: Two.

G. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.

1. Hardwired Points:
    a. Monitoring: On-off status
    b. Control: On-off operation
2. Communication Interface: Comply with ASHRAE 135 (MS-TP). Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

3. Refer to Section 230923 and 230993, for requirements, select features to communicate with BAS, and accomplish control intent.

2.5 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.

B. EMI/RFI Filtering:

1. CE marked; certify compliance with IEC 61800-3.

~~2.6 BYPASS SYSTEMS~~

~~A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.~~

~~B. Bypass Mode:~~

~~1. Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor, and retransfer shall only be allowed with the motor at zero speed.~~
~~2. Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic-control system feedback.~~

~~C. Bypass Controller:~~

~~1. Two-Contactor-Style Bypass: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode].~~

~~a. Bypass Contactor: Load-break, IEC rated contactor.~~
~~b. Output Isolating Contactor: Non-load-break, IEC-rated contactor.~~
~~c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.~~

~~D. Bypass Contactor Configuration: Full-voltage (across-the-line) type.~~

~~1. NORMAL/BYPASS selector switch.~~

~~2. HAND/OFF/AUTO selector switch.~~
~~3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.~~
~~4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.~~

~~a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.~~
~~b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.~~

~~5. Control Circuits: 120-V ac; obtained from control power source of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.~~
~~6. Overload Relays: NEMA ICS 2.~~

~~a. Bimetallic Overload Relays:~~

~~1) Inverse-time-current characteristic.~~
~~2) class 10 tripping characteristic.~~
~~3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.~~
~~4) Ambient compensated.~~
~~5) Automatic resetting.~~

~~b. NC isolated overload alarm contact.~~
~~c. External overload, reset push button.~~

2.7 OPTIONAL FEATURES

A. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

B. Remote digital operator kit.

C. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a notebook computer.

2.8 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1 <Insert type>.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.9 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

1. Push Buttons: Unguarded.
2. Pilot Lights: Push to test.
3. Selector Switches: Rotary type.
4. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

B. Reversible NC/NO bypass contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Supplemental Digital Meters:

1. Elapsed-time meter.
2. Kilowatt meter.
3. Kilowatt-hour meter.

F. Cooling Fan and Exhaust System: For NEMA 250, Type 1, UL 508 component recognized: Supply fan, with composite intake and exhaust grills and filters; 120 V ac; obtained from integral CPT.

2.10 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to its specified motor.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

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

3.2 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Division 26 specification section for Hangers and Supports for Electrical Systems.

B. Seismic Bracing: Comply with requirements specified in Division 26 specification section for "Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible-switch VFC.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 specification section for "Fuses."

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Comply with NECA 1.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices[and facility's central-control system]. Comply with requirements in Division 26 specification section for "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.4 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 26 specification section for "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. VFCs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to assist with startup service.

1. Complete installation and startup checks according to manufacturer's written instructions. Submit reports for acceptance to construction manager

3.7 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Construction Manager before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers.

E. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 specification section for "Coordination Studies."

F. Set field-adjustable pressure switches.

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 232923

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round ducts and fittings.
4. Double-wall round and flat-oval ducts and fittings.
5. Sheet metal materials.
6. Duct liner.
7. Sealants and gaskets.
8. Hangers and supports.

1.2 DEFINITIONS

A. OSHPD: Office of Statewide Health Planning and Development (State of California).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Sustainable Design Submittals:

1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Product Data: For adhesives, indicating VOC content.
4. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
5. Product Data: For sealants, indicating VOC content.
6. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
7. Laboratory Test Reports: For antimicrobial coatings, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections,

components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top and bottom of ducts.
5. Dimensions of all duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

D. Delegated Design Submittals:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, for selecting hangers and supports and any required seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: A single set of plans, generated with electronic drafting software (AutoDesk) or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades. Refer to Section 230500.

B. Welding certificates.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Provide work in accordance with Ohio Mechanical Code 2017, and Authority Having Jurisdiction.

B. Provide work per The Sheet Metal and Air Conditioning Contractors' National Association, SMACNA, standards:

1. HVAC Duct Construction Standards – Metal and Flexible, 4th Ed.
2. HVAC Air Duct Leakage Test Manual, 2nd Ed.
3. IAQ Guidelines for Occupied Buildings Under Construction, 2nd Ed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints are to withstand the effects of gravity and seismic loads, where required, and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7,where required.

C. Seismic Performance: Ductwork to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7, See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
2. Component Importance Factor: 1.0.

D. Airstream Surfaces: Surfaces in contact with airstream comply with requirements in ASHRAE 62.1.

E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

F. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

G. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation, duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC

Duct Construction Standards - Metal and Flexible."

1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams are to be Pittsburgh lock seams unless otherwise specified for specific application.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:

1. Ductmate Industries, Inc; a DMI company
2. McGill AirFlow LLC
3. MKT Metal Manufacturing
4. SHAPE Manufacturing Inc]
5. Sheet Metal Connectors, Inc.

B. Source Limitations: Obtain double-wall rectangular ducts and fittings from single manufacturer.

C. Rectangular Ducts: Fabricate ducts with indicated dimensions for clear internal dimensions of the inner duct.

D. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.

E. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular

Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.

F. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams are to be Pittsburgh lock seams unless otherwise specified for specific application.

G. Interstitial Insulation, Fibrous Glass: Duct liner complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F conductivity at 75 deg F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

H. Interstitial Insulation, Flexible Elastomeric: Duct liner complying with ASTM C534/C534M, Type II for sheet materials, and with NFPA 90A or NFPA 90B.

1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F conductivity at 75 deg F mean temperature.

I. Inner Duct: Minimum 24-gauge solid galvanized sheet steel.

2.4 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct

Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 48 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.5 MEDIUM PRESSURE HIGH VELOCITY ROUND DUCT AND FITTINGS

A. Provide in accordance with SMACNA HVAC Duct Construction Standard and ASHRAE handbooks, except as indicated. Provide duct material, gages, reinforcing, sealing, for 8" WG positive/negative pressure.

B. Single wall round ducts shall be spiral lockseam construction, G90 galvanized steel of minimum 22 gauge thickness.

C. Fittings shall be solid welded construction; and shall be by the same manufacturer as the ductwork lengths.

D. Construct tees, bends, and elbows with radius of not less than 1.5 times the width of duct on centerline.

E. Transform duct sizes gradually, not exceeding 15° divergence/convergence.

F. Seal all transverse joints, longitudinal seams, and penetrations.

2.6 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Linx Industries; a DMI company (formerly Lindab)
2. McGill AirFlow LLC
3. MKT Metal Manufacturing
4. SEMCO, LLC; part of FlaktGroup

5. SPOT
6. Set Duct Manufacturing
7. SHAPE Manufacturing Inc.
8. Sheet Metal Connectors, Inc

B. Source Limitations: Obtain double-wall round[and flat oval] ducts and fittings from single manufacturer.

C. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

D. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   a. Transverse Joints in Ducts Larger Than 48 Inches in Diameter: Flanged.

3. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
   b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

4. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Inner Duct: Minimum 24-gauge solid galvanized sheet steel.

F. Interstitial Insulation, Fibrous Glass: Duct liner complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity:0.27 Btu x in./h x sq. ft. x deg F conductivity at

75 deg F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

2.7 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials are to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.

D. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating is to be applied to the exterior surface.
2. Antimicrobial compound is to be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound is to have a hardness of 2H, minimum, when tested in accordance with ASTM D3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: [Black] [White].
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

E. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

F. Tie Rods: Galvanized steel, 1/4-inch- minimum diameter for lengths 36 inches or less; 3/8-inch- minimum diameter for lengths longer than 36 inches.

2.8 DUCT LINER

A. Fibrous-Glass-Free, Natural-Fiber Duct Liner: Made from partially recycled cotton or polyester products and containing no fiberglass. Airstream surface overlaid with fire-resistant facing to prevent surface erosion by airstream, complying with NFPA 90A or NFPA 90B. Treat natural-fiber products with antimicrobial coating.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:

    a. Acoustical Surfaces, Inc.
    b. Ductmate Industries, Inc; a DMI company
    c. Johns Mansville
    d. Nomaco
    e. Knauf

2. Source Limitations: Obtain fibrous-glass-free, natural-fiber duct liner from single manufacturer.
3. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature when tested in accordance with ASTM C518.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with ASTM E84; certified by an NRTL.
5. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

    a. Adhesive shall have a VOC content of 80 g/L or less.

B. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure

butted-edge overlapping.

5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm or greater.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
   a. Fan discharges.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.
9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
   a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.
10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.9 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets are to be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare),

stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
8. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
10. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
11. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

E. Round Duct Joint O-Ring Seals:

1. Seal is to provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and is to be rated for10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.10 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

C. Where ductwork is exposed to public view in finished specs, duct hangers shall be single and double rod connection point band type hangers for round and flat-oval applications, continuous galvanized steel band, minimum 2” wide and minimum 14 ga material, tightly formed to specific cross-section contour of all ducts.

D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

E. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless Steel Ducts: Stainless steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

J. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

K. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

L. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

M. Branch Connections: Use lateral or conical branch connections.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

F. Where ductwork is exposed to public view in finished specs, duct hangers shall be single and double rod connection point band type hangers for round and flat-oval applications, continuous galvanized steel band, locking nuts and threaded rod on top where less noticeable to occupants, paint ready.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
3. Conditioned Space, 2-inch WC or less, Supply-Air Ducts Seal Class B.
4. Conditioned Space, Exhaust Ducts: Seal Class B.
5. Exhaust duct pressure over 2” WC Seal Class A.
6. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.
6. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports, trim excess rod and file smooth, within 1-1/2”.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraint installation requirements.

3.6 DUCTWORK CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in specification sections in Division 9 for Painting.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
   1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
   2. Test the following systems:
      a. Ducts with a Pressure Class Higher Than 4-Inch wg: Test all duct sections.
      b. Ducts with a Pressure Class of 4 Inch wg or less: Test representative duct sections totaling no less than 50 percent of total installed duct area.
   3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
   4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.

5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven business days advance notice to construction manager for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

   a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media is to not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.9 DUCT CLEANING

A. Clean new duct system(s) where cleanliness test is not accepted, before testing, adjusting, and balancing.

B. Use duct cleaning methodology as indicated in NADCA ACR.

C. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

D. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

E. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

F. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.10 STARTUP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.11 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

B. Supply Ducts:

1. Ducts Connected to Variable-Air-Volume Air-Handling Units:

a. Pressure Class: Positive 4 inch wg.
b. Minimum SMACNA Seal Class: B.

C. Return Ducts:

1. Ducts Connected to Air-Handling Units

a. Pressure Class: Positive or negative 3 inch wg.
b. Minimum SMACNA Seal Class: C.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 2 inch wg.
b. Minimum SMACNA Seal Class: C if negative pressure, and B if positive pressure.

2. Ducts Connected to Fans Exhausting Fumes (ASHRAE 62.1, Class 3 and Class

a. Pressure Class: Positive or negative 6 inch wg.
b. Minimum SMACNA Seal Class A.

E. Outdoor-Air Ducts:

1. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 3 inch wg.
b. Minimum SMACNA Seal Class: B.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

G. Liner:

1. Return-Air Ducts: Fibrous-glass-free, natural fiber, 1 inch thick.
2. Transfer Ducts: Fibrous-glass-free, natural fiber, 1 inch thick.

H. Elbow Configuration:

1. Rectangular Duct - Requirements for Different Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.

b. Velocity 1000 to 1500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.

2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.

c. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

2. Rectangular Duct - Requirements for All Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 10 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 12 Inches and Larger in Diameter: Standing seam or welded.

I. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Conical spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees."

a. Velocity to 1500 fpm: Conical tap.
b. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manual volume dampers.
2. Control dampers.
3. Fire dampers.
4. Flange connectors.
5. Duct silencers.
6. Flexible connectors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Detail duct accessories' fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Control-damper installations.
d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Duct security bars.
f. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, or BIM model, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved. Refer to Section 230500.

B. Source quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 90A and NFPA 90B.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Performance:
    a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.
2. Construction:
    a. Linkage out of airstream.
    b. Suitable for horizontal or vertical airflow applications.
3. Frames:
    a. Hat-shaped, 16-gauge- thick, galvanized sheet steel
    b. Mitered and welded corners.
    c. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized steel; 16 gauge thick.
5. Blade Axles: Galvanized steel.
6. Bearings:
    a. Molded synthetic or stainless steel sleeve.
    b. Dampers mounted with vertical blades to have thrust bearing at each end

of every blade.

7. Tie Bars and Brackets: Galvanized steel.
8. Locking device, with graduation marking scale, to hold damper blades in a fixed position without vibration.

B. Jackshaft:

1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle, made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

D. High Velocity Hand Dampers with Quadrant Regulator:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers offering products that may be incorporated into the Work:

   a. Ruskin (model CDR25)
   b. American Warming and Ventilating
   c. Greenheck
   d. McGill AirFlow LLC

2. Designed and constructed for balancing of air flows in round ducts with velocities up to 4,000 feet per minute, and maximum 10 inches WG. Maximum 10 cfm lost at 4 inches WG.
3. 12 gauge G90 galvanized steel frame: single skin round damper blade of 12 gauge G90 steel, fastened to ½” plated steel axel, extended beyond frame through stainless steel pressed bearings.
4. Outboard heavy gauge plated steel support bracket for extended shaft, with retaining shaft clip, minimum 5 inch adjustment handle of heavy gauge plated steel, nut-bolt fastened to extended shaft, graduated slotted faceplate and locking wing nut to securely hold adjustment position.

2.3 CONTROL DAMPERS

A. General Requirements:

1. Unless otherwise indicated, use parallel-blade configuration for two-position control, equipment isolation service, and opposed blade for modulating and positioning, such as when mixing two airstreams. For other applications, use opposed-blade configuration.

2. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.
3. Refer to Section 230923.12 “Control Dampers”.

B. Performance:

1. AMCA Certification: Test and rate in accordance with AMCA 511.
2. Leakage:

    a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.
    b. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
    c. Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.
    d. Class III: Leakage shall not exceed 40 cfm/sq. ft. against 1-inch wg differential static pressure.

3. Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Temperature: Minus 25 to plus 180 deg F.
5. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

C. Construction:

1. Linkage out of airstream.
2. Suitable for horizontal or vertical airflow applications.
3. Frames:

    a. Hat, U, or angle shaped.
    b. 0.08-inch- thick extruded aluminum or 16-gauge- thick, galvanized sheet steel.
    c. Mitered and welded, or Interlocking, gusseted corners.
    d. Flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:

    a. Multiple blade with maximum blade width of 6 inches.
    b. Galvanized steel or Aluminum.
    c. 16-gauge- thick single skin.

5. Blade Edging Seals:

    a. Replaceable Closed-cell neoprene
    b. Inflatable seal blade edging, or replaceable rubber seals.

6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch diameter; galvanized steel.
8. Blade-Linkage Hardware: Zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of air stream.
9. Bearings:

a. Molded synthetic or stainless steel sleeve.
b. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.

2.4 FIRE DAMPERS

A. Type: Static; rated and labeled in accordance with UL 555 by an NRTL.

B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.

C. Fire Rating: according to rating of building element where applied.

D. Frame: Curtain type with blades outside airstream, fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with UL listing.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed galvanized sheet steel, interlocking, full-length steel blade connectors. Material gauge is to be in accordance with UL listing.

H. Horizontal Dampers: Include blade lock and stainless steel closure spring.

I. Heat-Responsive Device:

1. Replaceable, temperature rated, fusible links.

2.5 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gauge and Shape: Match connecting ductwork.

2.6 DUCT SILENCERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers offering products that may be incorporated into the Work:

1. FläktGroup
2. Flexmaster U.S.A., Inc
3. IAC Acoustics

4. McGill AirFlow LLC
5. Metal Form Manufacturing LLC; United Enertech Corp
6. Price Industries Limited
7. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
8. Vibro-Acoustics

B. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
4. Bearing AMCA's Certified Ratings Seal for prefabricated silencer sound and air performance.

C. Shape:

1. Rectangular straight with splitters or baffles.
2. Round straight with center bodies or pods.
3. Rectangular elbow with splitters or baffles.
4. Round elbow with center bodies or pods.
5. Rectangular transitional with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A653/A653M, G90, galvanized sheet steel, 0.034 inch thick.

E. Round Silencer Outer Casing: ASTM A653/A653M, G90 galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 22 gauge thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 20 gauge thick.

F. Inner Casing and Baffles: ASTM A653/A653M, G90 galvanized sheet metal, 22 gauge thick, and with 1/8-inch diameter perforations.

G. Special Construction:

1. Suitable for outdoor use.
2. High transmission loss to achieve STC 45.

H. Connection Sizes: Match connecting ductwork unless otherwise indicated.

I. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. Film-lined type with fill material.

a. Fill Material: Inert and vermin-proof moisture-proof nonfibrous material.
b. Erosion Barrier: Polymer bag enclosing fill, heat-sealed before assembly.

3. Lining: none.

J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Joints: Lock formed and sealed or flanged connections.
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.

K. Accessories:

1. Factory-installed end caps to prevent contamination during shipping.
2. Removable splitters.
3. Airflow-measuring devices.

L. Source Quality Control:

1. Test in accordance with ASTM E477.
2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000 fpm face velocity.
3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

M. Capacities and Characteristics:

1. Configuration: Straight.
2. Shape: Rectangular, or Round.
3. Attenuation Mechanism: Acoustical non-fiberous.
4. Maximum Pressure Drop: 0.30 inch wg at design air flow
5. Casing:

a. Attenuation: Standard.

6. End Connection: 1-inch slip joint or Flange.

2.7 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements

B. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Materials: Flame-retardant or noncombustible fabrics.

E. Coatings and Adhesives: Comply with UL 181, Class 1.

F. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

G. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

2.8 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.

C. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.

C. Install [backdraft] [control] dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.

E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.

H. Install fire[and smoke] dampers in accordance with UL listing.

I. Connect ducts to duct silencers rigidly.

J. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream[and downstream] from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-ft.spacing.
8. Upstream and downstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. For grease ducts, install at locations and spacing as required by NFPA 96.
11. Control devices requiring inspection.
12. Elsewhere as indicated.

K. Install access doors with swing against duct static pressure.

L. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.

3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

M. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

N. Install flexible connectors to connect ducts to equipment.

O. For fans developing static pressures of 5 inches wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

P. Install duct test holes where required for testing and balancing purposes.

Q. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors, and verify that size and location of access doors are adequate to perform required operation.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233416 - CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pressure blowers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
2. Rated capacities, operating characteristics, and furnished specialties and accessories.
3. Certified fan performance curves with system operating conditions indicated.
4. Certified fan sound-power ratings.
5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
6. Material thickness and finishes, including color charts.
7. Dampers, including housings, linkages, and operators.
8. Fan speed controllers.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and wind restraints.

C. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Fan room layout and relationships between components and adjacent structural and mechanical elements, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: For fans, accessories, and components, from manufacturer for vibration control. Refer to specification Section 230548.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity, and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Refer to Section 230500.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in normal operation, emergency operation, and maintenance manuals with replacement parts listing.

PART 2 - PRODUCTS

2.1 BASIC REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Capacities and Characteristics:

1. Refer to schedules on plans
2. Motor:

2.2 RADIAL PRESSURE BLOWER EXHAUST FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cincinnati Fan
2. Acme Engineering & Manufacturing Corp.
3. Central Blower Company
4. Lau Fan

5. New York Blower Company (The)
6. Donaldson (Torrit)

B. Radial blade pressure blower, cast aluminum with integral cast hub and blades.

1. Stamped steel housing of 14 gauge minimum steel, round inlet and round discharge ready for direct connection to ductwork, without transition fitting. Baked powder coat finish on interior and outer surfaces of blower housing
2. Turned polished steel ground shafts with rust preventative coating, fan motor and bearing vibration levels under 1.5 mills displacement at design speed.
3. Heavy-duty, self-aligning grease lubricated ball bearings mounted in cast iron pillow blocks

C. Accessories:

1. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
2. Pitot airflow measurement traverse probe, multiple probe pitot totals static and pressure sensing to provide measurement of airflow in a round duct to within +/- 3% of actual.

a. Multiple ports equidistant distribution along length of each probe
b. Separate probes cover entire round duct cross section, manifolded to deliver velocity pressure measurement that identifies flow rate in cfm.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

B. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

2.4 SOURCE QUALITY CONTROL

A. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.

B. AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.

C. AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.

D. Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Support duct-mounted and other hanging centrifugal fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
3. Support, connect, and mitigate transmission of vibrations and sound to building and ductwork following manufacturer’s recommendations.

E. Coordinate wall penetrations and flashing with wall construction.

F. Install units with clearances for service and maintenance.

G. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK AND PIPING CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

D. Provide straight sections of inlet and exhaust ductwork required for proper operation of fan and accurate reading for probes in accordance with manufacturers’ recommendations.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Division 26 specification sections for Low-Voltage

Electrical Power Conductors and Cables.

B. Ground equipment according to Division 26 specification sections for Grounding and Bonding for Electrical Systems.

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Division 26 specification sections for Identification for Electrical Systems.
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Division 26 specification sections for Control-Voltage Electrical Power Cables.

3.5 STARTUP SERVICE:

A. Engage a factory-authorized service representative to assist in startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
6. For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.

11. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

A. Adjust speed through variable frequency drive control to cfm flow required by pressure readings at pitot probes, and conversion to cfm.

B. Lubricate bearings.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative, and using report forms and procedures from the various manufacturers.

1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Fans and components will be considered defective if they do not pass tests and inspections.

B. Prepare test and inspection reports.

3.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fans.

END OF SECTION 233416

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Modulating, single-duct air terminal units.
2. Series fan-powered air terminal units.
3. Casing liner.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

1. Product Data: For adhesives, indicating VOC content.
2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
3. Product data showing compliance with ASHRAE 62.1.

C. Shop Drawings: For air terminal units.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

D. Delegated Design Submittal: For vibration isolation and supports, and seismic restraints, where required; indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Materials, fabrication, assembly, and spacing of hangers and supports.
2. Design Calculations: Calculate requirements for selecting vibration isolators, supports, and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, indicating the items described in this Section, and coordinated with all building trades. Refer to Section 230500.

B. Seismic Qualification Data: For air terminal units, 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.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 1 specification sections for Operation and Maintenance Data, include the following:

a. Instructions for resetting minimum and maximum air volumes.
b. Instructions for adjusting software set points.

1.5 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. Fan-Powered-Unit Filters: Furnish one spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a Qualified Electrical Testing Laboratory, and marked for intended location and application.

B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

D. Delegated Design: Engage a qualified professional engineer to design vibration isolation, supports, and seismic restraints, where required; including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

E. Seismic Performance: Air terminal units shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified
2. Component Importance Factor: 1.0.

2.2 TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Titus
2. Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.
3. ENVIRO-TEC
4. Krueger-HVAC
5. METALAIRE, Inc
6. Price Industries Limited
7. Tuttle & Bailey

2.3 MODULATING, SINGLE-DUCT AIR TERMINAL UNITS

A. Description: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

B. Casing: Minimum 22-gauge thick galvanized steel.

1. Casing Liner: Comply with requirements in "Casing Liner" Article below for Casing Liner, Fibrous Glass" with "Antimicrobial Erosion-Resistant Coating" Subparagraph.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.

C. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.

D. Velocity Sensors: Multipoint array with velocity inlet sensors.

E. Attenuator Section: Casing material and thickness matching associated air terminal unit casing. Provide absorptive attenuator integral with the air terminal unit, with noise transmission loss performance as required in schedules on Drawings.

F. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch. Include manual air vent and drain valve. Provide hydronic heating coils for air terminal units scheduled on Drawings.

G. Controls:

1. Electronic Damper Actuator: 24 V, fail in last position.
2. Electronic Thermostat: Wall-mounted electronic type with no display; refer to specification Section 230923.27
3. Electronic Air Volume Controller: Pressure-independent analog electronic controller, factory calibrated and field adjustable to minimum and maximum air volumes; provides consistent airflow to the space in response to electronic thermostat signal while compensating for inlet static-pressure variations of up to 4 inches wg; includes a multipoint velocity sensor at air inlet. Refer to specification Sections 230923 and 230923.12.

H. Direct Digital Controls:

1. Terminal Unit Controller: Pressure-independent, VAV controller and integrated actuator, and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum, heating and maximum primary air volumes.
   a. Occupied and unoccupied operating mode.
   b. Remote reset of airflow or temperature set points.
   c. Adjusting and monitoring with portable terminal.
   d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controllers, integrated actuators, and room sensors to be furnished under Section 230923 "Direct Digital Controls (DDC) for HVAC" and 230923.12 “Control Dampers”.
3. Control Sequence: See Section 230993 "Sequence of Operation for HVAC" and drawings.

2.4 SERIES FAN-POWERED AIR TERMINAL UNITS

A. Description: Volume-damper assembly and centrifugal fan in series arrangement inside unit casing with control components inside a protective metal shroud.

1. Designed for quiet operation.
2. Low-profile design.

B. Casing: Minimum 20-gauge- thick galvanized steel.

1. Casing Liner: Comply with requirements in "Casing Liner" Article below for non fibrous, natural cotton-based interior lining insulation, 1” thick for thermal resistance and acoustical dampening.
2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
5. Fan: Forward-curved centrifugal.

C. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.

D. Velocity Sensors: Multipoint array with velocity sensors in air inlet.

E. Fan Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Type: Electronically commutated motor, brushless DC.
3. Fan-Motor Assembly Isolation: Rubber isolators.
4. Enclosure: Totally enclosed, fan cooled.
5. Motor Bearings: permanently lubricated.
6. Efficiency: Premium efficient as defined by NEMA MG-1.
7. Service Factor: 1.15
8. Motor Speed: Variable speed.
   a. Speed Control: Infinitely adjustable with electronic controls.
9. Electrical Characteristics:
   a. 208 Volts
   b. Phase: 1
   c. Hertz: 60.

F. Filters:

1. Flat Glass Fiber: Factory-fabricated, self-supported disposable air filter with holding frames. Provide MERV 6 filters with minimum efficiency reporting value is to be in accordance with ASHRAE 52.

G. Attenuator Section, Inlet: Casing material and thickness matching associated air terminal unit casing. Provide absorptive attenuator integral with the plenum inlet, filter replacement accessible without removal of inlet attenuator.

H. Attenuator Section, Outlet: Casing material and thickness matching associated air terminal unit casing, S-slip and drive for downstream duct connection. Provide absorptive attenuator integral with the air terminal unit, with noise transmission loss performance as required in schedules on Drawings.

I. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch. Include manual air vent and drain valve. Locate coil in discharge outlet airstream. Provide hydronic heating coils for air terminal units scheduled on Drawings.

J. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

K. Electronic Controls:

1. Electronic Damper Actuator: 24 V, fail in last position.
2. Electronic Thermostat: Wall-mounted electronic type with no display
3. Electronic Air Volume Controller: Pressure-independent analog electronic controller, factory calibrated and field adjustable to minimum, heating and maximum air volumes; provides consistent airflow to the space in response to electronic thermostat signal while compensating for inlet static-pressure variations of up to 4 inches wg; includes a multipoint velocity sensor at air inlet. Refer to specification Sections 230923 and 230923.12.

L. Direct Digital Controls:

1. Terminal Unit Controller: Pressure-independent, VAV controller and integrated actuator, and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
    a. Occupied and unoccupied operating mode.
    b. Remote reset of airflow or temperature set points.
    c. Adjusting and monitoring with portable terminal.
    d. Communication with temperature-control system specified in Section 230923 "Instrumentation and Control for HVAC" and Section 230923.12 “Control Dampers”
2. Room Sensor: Wall mounted with no display; and access port for connection of portable operator terminal. Refer to Section 230923,27 “Temperature Instruments”
3. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal unit manufacturer; unit controller, actuators, and room sensors are to be furnished under Section 230923 "Direct Digital Control (DDC) for HVAC", and Section 230923.12 “Controls Dampers”.

M. Control Sequence: See Section 230993.11 "Sequence of Operation for HVAC" and Drawings for control sequences.

2.5 CASING LINER

1. Antimicrobial, Erosion-Resistant.
2. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916. Adhesive shall have a VOC content of 80 g/L or less.

2.6 SOURCE QUALITY CONTROL

A. AHRI 880 Certification: Test, rate, and label assembled air terminal units in accordance with AHRI 880

B. AHRI 880: Test and rate assembled air terminal units in accordance with AHRI 880.

C. Water Coils: Factory pressure test to 300 psig in accordance with AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" and Section 233113 "Metal Ducts" for hangers and supports.

B. Install air terminal units according to NFPA 90A.

C. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

D. Carefully coordinate locations of units to be positioned between existing floor and roof structural elements (beams and trusses), installing as high as possible, yet allowing service clearances for regular maintenance and installation of primary inlet ductwork and downstream outlet ductwork, and attenuators.

3.2 PIPING CONNECTIONS

A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

B. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," and connect heating coils to supply piping with isolation valve, strainer, and union or flange; and to return piping with pressure-independent control valve, union or flange, and isolation valve.

3.3 DUCTWORK CONNECTIONS

A. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

B. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories", and Section 233346 “Flexible ducts”

3.4 ELECTRICAL CONNECTIONS

A. Install field power to each air terminal unit electrical power connection. Coordinate with air terminal unit manufacturer and installers.

B. Connect wiring in accordance with Division 26 specification sections for Low-Voltage Electrical Power Conductors and Cables.

C. Ground equipment in accordance with Division 26 specification sections for Grounding and Bonding for Electrical Systems.

D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Division 26 specification sections for Identification for Electrical Systems.
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Division 26 specification sections for Control-Voltage Electrical Power Cables.

3.6 IDENTIFICATION

A. Label each air terminal unit with drawing designation, nominal airflow, maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.

2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.8 ADJUSTING

A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air terminal unit testing, adjusting, and balancing.

3.9 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

SECTION 237313.16 - INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulated, double-wall-casing, indoor, semi-custom air-handling units that are factory assembled using multiple section components, including the following:

1. Casings.
2. Fans, drives, and motors.
3. Coils.
4. Air filtration.
5. Dampers.
6. Sound attenuators.

1.2 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
    a. Include certified fan-performance curves with system operating conditions indicated.
    b. Include certified fan-sound power ratings.
    c. Include fan construction and accessories.
    d. Include motor ratings, electrical characteristics, and motor accessories.
6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include dampers, including housings, linkages, and operators.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each type and configuration of indoor, semi-custom air handling unit.

1. Include plans, elevations, sections, and [mounting] [attachment] details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of indoor, semi-custom air-handling units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittal: For vibration isolation, supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators[, supports, and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates for air-handling units, 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.
4. Restraint of internal components.

C. Source quality-control reports.

D. Startup service reports.

E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.5 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of indoor, semi-custom air-handling units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: One year from date of Owner acceptance of completion.

PART 2 - PRODUCTS PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Division 1 specifications for Quality Requirements, to design vibration isolation and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

F. Structural Performance: Casing panels shall be self-supporting and capable of withstanding positive/negative 8-inch wg of internal static pressure, without exceeding a midpoint deflection of 0.0042 inch/inch of panel span.

G. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 8 inch wg.

2.2 INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:

1. Daikin
2. Carrier
3. Engineered Air
4. Trane

B. Unit Casings:

1. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.
2. Base Rail:
    a. Material: Galvanized steel.
    b. Height: 6 inches.
3. Casing Joints: Hermetically sealed at each corner and around entire perimeter.
4. Double-Wall Construction:

a. Outside Casing Wall:

1) Material, Galvanized Steel: Minimum 18 gauge thick.
2) Factory Finish: Provide manufacturer's standard finish.

b. Inside Casing Wall:

1) Material, G-90 galvanized Steel: Solid minimum 18 gauge thick.
2) Antimicrobial Coating: Applied during the manufacturing process. EPA approved, NSF approved.

5. Floor Plate:

a. Material, Galvanized Steel: 16 gauge thick.
b. Antimicrobial Coating: Applied during the manufacturing process. EPA approved, NSF approved.

6. Casing Insulation:

a. Materials: Injected polyurethane foam insulation
b. Casing Panel R-Value: Minimum R-13.
c. Insulation Thickness: 2 inches.
d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

7. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
8. Static-Pressure Classifications:

a. For Unit Sections Upstream of Fans: Minus 4-inch wg.
b. For Unit Sections Downstream and Including Fans: 4-inch wg

9. Panels, Doors, and Windows:

a. Panels:

1) Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
2) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow
3) Gasket: Neoprene, applied around entire perimeters of panel frames.
4) Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.

b. Doors:

1) Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
2) Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
3) Gasket: Neoprene, applied around entire perimeters of panel frames.

4) Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.

c. Locations and Applications:

1) Fan Section.
2) Coil Section.
3) Access Section.
4) Damper Section:
5) Filter Section:.
6) Mixing Section:
7) Controls:.

10. Condensate Drain Pans:

a. Construction:

1) Single-wall, stainless-steel sheet.
2) with foam insulation and moisture-tight seal.

b. Drain Connection:

1) Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
2) Minimum Connection Size: NPS 1.

c. Slope: Minimum 0.125-in./ft slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
d. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
e. Width: Entire width of water producing device.
f. Depth: A minimum of 2 inches deep.

C. Fan, Drive, and Motor Section:

1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
2. Fans: Airfoil centrifugal, galvanized steel; mounted on solid-steel shaft.

a. Shafts: With field-adjustable alignment.
b. Turned, ground, and polished hot-rolled steel with keyway.
c. Shaft Bearings:

1) Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with an L-50 bearing life rating, life of 200,000 hours according to ABMA 9.
2) Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and two-piece, cast-iron housing.

d. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

1) Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.

e. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
f. Mounting: For internal vibration isolation and seismic control. Factory-mount fans with manufacturer's standard[restrained] vibration isolation mounting devices having a minimum static deflection of 1 inch.
g. Flexible Connector: Factory fabricated to limit transmission of vibration to housing.

3. Drive, Belt: Factory-mounted, V-belt drive, with adjustable alignment and belt
4. Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
c. Enclosure Type: Open, dripproof or TEFC fan cooled.
d. Motor Bearings: grounded for use with VFD to limit impact of potentials, inverter duty.
e. Efficiency: Premium Efficient motors as defined in NEMA MG 1.
f. Motor Pulleys: Adjustable pitch for use with 5 hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
g. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
h. Mount unit-mounted disconnect switches on exterior of unit.

5. Comply with Section 232923 "Variable-Frequency Motor Controllers."
6. Variable-Frequency Motor Controller: Serving each fan individually.

a. Manufactured Units: Pulse-width modulated; constant torque, and variable torque for inverter-duty motors.
b. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range, 66 Hz. maximum voltage equals input voltage.
c. Mounted outside airstream in controls cabinet with hinged access door.
d. Meet UL Standard 95-5V
e. Unit Operating Requirements:

1) Internal Adjustability:

a) Minimum Speed: 5 to 25 percent of maximum rpm.

b) Maximum Speed: 80 to 100 percent of maximum rpm.
c) Acceleration: 0.1 to 999.9 seconds.
d) Deceleration:0.1 to 999.9 seconds.
e) Current Limit: 30 to minimum of 150 percent of maximum rating.

2) Self-Protection and Reliability Features:

a) Surge suppression.
b) Loss of input signal protection.
c) Under- and overvoltage trips.
d) Variable-frequency motor controller and motor-overload/overtemperature protection.
e) Critical frequency rejection.
f) Loss-of-phase protection.
g) Reverse-phase protection.
h) Motor-overtemperature fault.

3) Bidirectional autospeed search.
4) Torque boost.
5) Motor temperature compensation at slow speeds.

a) Panel-mounted operator station.
b) Historical logging information and displays.
c) Digital indicating devices.

6) Control Signal Interface: Electric.
7) Proportional Integral Directive (PID) control interface.
8) DDC system for HVAC Protocols for Network Communications: ASHRAE 135, fully communicating with the BAS, refer to section 230293.

f. Line Conditioning:

1) Input line conditioning.
2) Output filtering.
3) EMI/RFI filtering.

D. Coil Section:

1. General Requirements for Coil Section:

a. Comply with AHRI 410.
b. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
c. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
d. Coils shall not act as structural component of unit.

2. Preheat Coils:

a. Hot-Water Coils: Continuous circuit, Cleanable.

1) Piping Connections: Threaded, or flanged, same end of coil.
2) Tube Material: Copper, min .020 inch wall thickness.
3) Fin Type: Plate.
4) Fin Material: Copper.
5) Fin Spacing: Maximum 12 fins per inch.
6) Fin and Tube Joint: Silver brazed.
7) Headers and casings:
    a) Cast iron or heavy gauge formed galvanized steel channel with cleaning plugs and drain and air vent tappings extended to exterior of unit.
    b) Seamless copper tube with brazed joints, prime coated.
    c) Fabricated steel, with brazed joints, prime coated.
    d) Provide insulated cover to conceal exposed outside casings of headers.
8) Frames: Channel frame, 0.052-inch- thick, galvanized steel.
9) Coil Working-Pressure Ratings: 200 psig, 325 deg F.

3. Cooling Coils:
    a. Chilled-Water Coil: Continuous circuit, Cleanable.
        1) Piping Connections: Threaded or Flanged, same end of coil.
        2) Tube Material: Copper, min .020 inch wall thickness
        3) Fin Type: Plate.
        4) Fin Material: Copper.
        5) Fin Spacing: 0.125 inch.
        6) Fin and Tube Joint: Mechanical bond or Silver brazed.
        7) Headers and casings:
            a) Cast iron or heavy gauge formed galvanized steel channel with cleaning plugs and drain and air vent tappings extended to exterior of unit.
            b) Seamless copper tube with brazed joints, prime coated.
            c) Fabricated steel, with brazed joints, prime coated.
            d) Provide insulated cover to conceal exposed outside casings of headers.
        8) Frames: Channel frame, 0.052-inch- thick, galvanized steel.
        9) Working-Pressure Ratings: 200 psig, 325 deg F.

E. Air Filtration Section:
    1. Particulate air filtration
    2. High-efficiency particulate air (MERV 13) filtration"
    3. Panel Filters:
        a. Description: Pleated, self-supported, disposable air filters with holding frames.
        b. Filter Unit Class: UL 900.
        c. Media: Interlaced glass, synthetic or cotton fibers coated with

nonflammable adhesive.

d. Filter-Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.

4. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
5. Side-Access Filter Mounting Frames:

   a. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized steel.

      1) Prefilters: Incorporate an integral 2-inch- thick track with same access as primary filter.
      2) Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

F. Dampers:

1. Comply with requirements in Section 230923.12 "Control Dampers."
2. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel or aluminum dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with zinc-plated steel operating rods rotating in stainless steel sleeve, sintered bronze or nylon bearings mounted in a single galvanized-steel or extruded-aluminum frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg, leakage Class 1 tested, rated, and labeled in accordance with AMCA 511.
3. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
4. Electronic Damper Operators:

   a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
   b. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
   c. Operator Motors:

      1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
      2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
      3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
      4) Provide damper operator motors to fully communicate with BAS

system, HVAC Protocols for Network Communications: ASHRAE 135, refer to section 230293

d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
f. Size dampers for running torque calculated as follows:

1) Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
2) Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
3) Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.
4) Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
5) Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
6) Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

g. Coupling: V-bolt and V-shaped, toothed cradle.
h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
j. Power Requirements (Two-Position Spring Return): Refer to section 230923 for direct digital controls.
k. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
l. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
m. Temperature Rating: Minus 22 to plus 122 deg F.

5. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.
6. Combination Filter and Mixing Section:

a. Cabinet support members shall hold 2-inch thick, pleated, flat, permanent or throwaway filters.
b. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.

G. Refer to specification 230923 “Direct Digital Control (DDC) System for HVAC”, and 230993.11 “Sequence of Operation for HVAC DDC” for controls and operation of the unit.

2.3 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.

2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B 09.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000 hour salt-spray test according to ASTM B117.

1. Standards:

    a. ASTM B117 for salt spray.
    b. ASTM D2794 for minimum impact resistance of 100 in-lb.
    c. ASTM B3359 for cross hatch adhesion of 5B.

2. Application: Immersion or Spray.
3. Thickness: 1 mil.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.4 SOURCE QUALITY CONTROL

A. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.

B. AHRI 1060 Certification: Test, rate, and label air-handling units that include air-to-air energy recovery devices in accordance with AHRI 1060.

C. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label in accordance with AHRI 260 or AMCA 311.

D. Fan Aerodynamic Performance Rating: Factory test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210.

E. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.

F. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

G. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

H. Witnessed Casing Leakage Tests:

1. Pay for all expenses, for one representative designated by Owner, to travel to the factory to witness cabinet air-leakage testing on the specific assembled unit(s) prior to release for delivery to Project site.
2. If the unit(s) does not meet specified leakage requirements, perform factory modifications and retest. Do not release unit for shipment until tested leakage is measured to be within specified leakage and leakage testing report has been accepted by Owner's designated representative.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION, GENERAL

A. Equipment Mounting:
   1. Install air-handling units on concrete equipment room floor. Coordinate sizes and locations with actual equipment provided.
   2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
   3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Examine field conditions and determine how unit is to be shipped in separate modules in order to facilitate installation into existing room; factory designed and constructed for field assembly into a complete, operating unit.

C. Arrange installation of units to provide access space around air-handling units for service and maintenance.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

E. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

F. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange, strainer, at each coil supply connection. Install pressure-independent control valve and union or flange at each coil return connection.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Division 26 specifications for "Control-Voltage Electrical Power Cables."

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
7. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
8. Comb coil fins for parallel orientation.
9. Verify that proper thermal-overload protection is installed for electric coils.
10. Install new, clean filters.
11. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.7 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.9 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

D. Prepare test and inspection reports.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to assist in training for Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237313.16

SECTION 237343.16 - OUTDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes outdoor, semi-custom air-handling units that are factory assembled using multiple section components; including:

1. Unit casings.
2. Fan, drive, and motor section.
3. Coil section.
4. Air filtration section.
5. Dampers.
6. Roof curbs.
7. Intake and relief air openings.

1.2 DEFINITIONS

A. BAS: Building Automation System, as defined in section 230923.

1.3 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
    a. Include certified fan-performance curves with system operating conditions indicated.
    b. Include certified fan-sound power ratings.
    c. Include fan construction and accessories.
    d. Include motor ratings, electrical characteristics, and motor accessories.
6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics
8. Include selected hydronic control valves, with nominal sizes, connections, performance, WPD.
9. Include dampers, including housings, linkages, and operators.
10. Provide a complete list of all points data base for read-write to the BAS.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each outdoor, semi-custom air-handling unit.

1. Include plans, elevations, sections, and mounting, attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of outdoor, semi-custom air-handling units, as well as procedure and diagrams.
4. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittal: For unit supports to indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators and high wind restraints, brackets, fasteners, and for their design meeting requirements per ASCE/SEI 7.
2. Detail mounting, securing and fastening, and flashing unit curb to roof structure, indicate coordination required with roofing contractor for roof membrane system
3. Restraint details: Wind-detail, fabrication and attachment of wind restraints, brackets, steel and clips, fasteners, Show anchorage details and indicating quantities, sizes, depth of anchors and fasteners/anchors.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades. Refer to section 230500.

B. Sample Warranty: For manufacturer's warranty.

C. Seismic Qualification Data: Certificates for air-handling units, 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.

4. Restraint of internal components.

D. Wind Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer. Submit certification that the specified equipment will withstand high wind forces identified in the performance requirements article and per section 230548.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force 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. Source quality-control reports.

F. Startup service reports.

G. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of outdoor, semi-custom, air-handling unit that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Entire Unit: 2 years from the date of substantial completion

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: certification by a qualified professional engineer, as defined in division one specification sections for Quality Requirements, or a factory roof curb, associated clips, anchors and fasteners for high wind restraining of the unit and the curb.

1. Design air handling unit supports to comply with local wind and seismic performance requirements required by the authority having jurisdiction.

F. Structural Performance:

1. Casing Panels: Self-supporting and capable of withstanding positive/negative 8-inch wg internal static pressure, without exceeding a midpoint deflection of 0.0042 inch/inch of panel span.
2. Floor and Roof Panels: Self-supporting and capable of withstanding 300-lb static load at midspan, without exceeding a midpoint deflection of 0.0042 inch/inch
3. Roof Panels: Self-supporting and capable of withstanding a static snow load of 30 lb/sq. ft., without exceeding a midpoint deflection of 0.0042 inch/inch.

G. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 8-inch wg.

H. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified
2. Component Importance Factor: 1.0

I. Wind Performance: Air-handling units are to withstand the effects of wind determined in accordance with ASCE/SEI 7, as required by the local authority having jurisdiction

2.2 UNIT CASINGS

A. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.

B. Base Rail:

1. Material: Galvanized steel
2. Height: 6 inches.

C. Casing Joints: Hermetically sealed at each corner and around entire perimeter.

D. Double-Wall Construction:

1. Outside Casing Wall:
    a. Material, Galvanized Steel: Minimum 18 gauge thick.
    b. Factory Finish: Provide manufacturer's standard finish.
2. Inside Casing Wall:
    a. Material, G-90 Galvanized Steel: Solid, minimum 18 gauge thick.
    b. Antimicrobial Coating: Applied during the manufacturing process. EPA approved, NSF approved.

E. Floor Plate:
1. Material:
    a. Galvanized steel, minimum 18 gauge thick.
2. Antimicrobial Coating: Applied during the manufacturing process. EPA approved, NSF approved.

F. Roof: Cross-broken and pitched with "C" caps over joints to provide watertight seal.

G. Piping Vestibule: Insulated with same insulation and thickness as casing, 18 inches deep by full width of unit to completely enclose piping, valves, specialties. Building piping connections shall be made from within curb, up into vestibule, without any piping or valves or piping specialties exposed to the outdoors..

H. Casing Insulation:
1. Materials: injected polyurethane foam insulation.
2. Casing Panel R-Value: Minimum R-13.
3. Insulation Thickness: 2 inches.
4. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

I. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

J. Static-Pressure Classifications:
1. For Unit Sections Upstream of Fans: Minus 4 inch wg.
2. For Unit Sections Downstream and Including Fans: 4-inch wg.

K. Panels, Doors, and Windows:
1. Panels:
    a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
    b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow
    c. Gasket: Neoprene, applied around entire perimeters of panel frames.

d. Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.

2. Doors:

   a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
   b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
   c. Gasket: Neoprene, applied around entire perimeters of panel frames.
   d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.

3. Locations and Applications:

   a. Fan Section:.
   b. Coil Section:.
   c. Access Section:
   d. Damper Section:
   e. Filter Section:.
   f. Piping vestibules
   g. Mixing Section.
   h. Controls.

4. Convenience Outlets: One 20-A duplex GFCI receptacle per location with junction box located on outside casing wall.

L. Condensate Drain Pans:

1. Location: Each type of cooling coil ~~[heat wheel]~~.
2. Construction:

   a. Single-wall, stainless-steel sheet, with foam insulation and moisture-tight seal.

3. Drain Connection:

   a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
   b. Minimum Connection Size: NPS 1.

4. Slope: Minimum 0.125-in./ft to comply with ASHRAE 62.1 in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
5. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.

6. Width: Entire width of water producing device.
7. Depth: A minimum of 2 inches deep.
8. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
9. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.3 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Fans: Airfoil centrifugal, galvanized steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.
   a. Turned, ground, and polished hot-rolled steel with keyway.
2. Shaft Bearings:
   a. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with an L-50 rated life of 200,000 hours according to ABMA 9.
   b. Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and two-piece, cast-iron housing with grease lines extended to outside
   c. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit and an L-50 rated life of 200,000.
3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
   a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
4. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
5. Mounting: For internal vibration isolation and seismic control. Factory-mount fans with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch.
6. Shaft Lubrication Lines: Extended to a location outside the casing.
7. Flexible Connector: Factory fabricated to limit transmission of vibration to unit, building, ductwork.

C. Drive, Direct: Factory-mounted, direct drive.

D. Motors:

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Enclosure Type: Totally enclosed, fan cooled, ECM motors.
4. Efficiency: Premium efficient as defined in NEMA MG 1
5. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
6. Mount unit-mounted disconnect switches protected from weather.
7. Variable-Frequency Motor Controller: Serving each fan individually.
    a. Manufactured Units: Pulse-width modulated; constant torque, and variable torque for inverter-duty motors.
    b. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range, 66 Hz. maximum voltage equals input voltage.
    c. Mounted outside airstream, protected from weather, in controls cabinet with hinged access door.
    d. Meet UL Standard 95-5V
    e. Unit Operating Requirements:
        1) Internal Adjustability:
            a) Minimum Speed: 5 to 25 percent of maximum rpm.
            b) Maximum Speed: 80 to 100 percent of maximum rpm.
            c) Acceleration: 0.1 to 999.9 seconds.
            d) Deceleration:0.1 to 999.9 seconds.
            e) Current Limit: 30 to minimum of 150 percent of maximum rating.
        2) Self-Protection and Reliability Features:
            a) Surge suppression.
            b) Loss of input signal protection.
            c) Under- and overvoltage trips.
            d) Variable-frequency motor controller and motor-overload/overtemperature protection.
            e) Critical frequency rejection.
            f) Loss-of-phase protection.
            g) Reverse-phase protection.
            h) Motor-overtemperature fault.
        3) Bidirectional autospeed search.
        4) Torque boost.
        5) Motor temperature compensation at slow speeds.
            a) Panel-mounted operator station.
            b) Historical logging information and displays.
            c) Digital indicating devices.

6) Control Signal Interface: Electric.
7) Proportional Integral Directive (PID) control interface.
8) DDC system for HVAC Protocols for Network Communications: ASHRAE 135, fully communicating with the BAS, refer to section 230293.

f. Line Conditioning:

1) Input line conditioning.
2) Output filtering.
3) EMI/RFI filtering.

8. Comply with Section 232923 "Variable-Frequency Motor Controllers."

2.4 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with AHRI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
4. Coils shall not act as structural component of unit.

B. Preheat Coils:

1. Hot-Water Coils; Continuous circuit , Cleanable.

a. Piping Connections: Threaded or Flanged, integral to cabinetry.
b. Tube Material: Copper.
c. Fin Type: Plate.
d. Fin Material: Copper.
e. Fin Spacing: Maximum 12 fins per inch.
f. Headers:

1) Cast iron or heavy gauge galvanized steel formed channel with cleaning plugs and drain and air vent tappings
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.

g. Frames: Channel frame, 0.052-inch- thick, galvanized galvanized steel 0.079-inch- thick, minimum.
h. Coil Working-Pressure Ratings: 200 psig, 325 deg F.
i. Coating: None.

C. Cooling Coils:

1. Chilled-Water Coil: Continuous circuit, Cleanable.

a. Piping Connections: Threaded or flanged, integral to cabinetry.
b. Tube Material: Copper.

c. Fin Material: copper.
d. Fin and Tube Joint: Mechanical bond.
e. Headers:
    1) Cast iron or heavy gauge galvanized steel formed channel with cleaning plugs and drain and air vent tappings internal to cabinetry
    2) Seamless copper tube with brazed joints, prime coated.
    3) Fabricated steel, with brazed joints, prime coated.
    4) Provide insulated cover, casings of headers to be fully within unit cabinetry.
f. Frames: Channel frame, 0.052-inch- thick, galvanized steel.
g. Working-Pressure Ratings: 200 psig, 325 deg F.

D. Hydronic package:

1. Factory pre-assembled, with insulated piping through unit cabinet to coil headers; unions, valves, piping fittings positioned within piping vestibule that is part of the unit cabinetry, out of weather. Capped hydronic connection to field piping within vestibule ready for field connection to building hydronic system from curb bottom openings.
2. Provide modulating, pressure-independent, control valve meeting the requirement of specification section 230923.11 “Control Valves”.

2.5 AIR FILTRATION SECTION

A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

B. High-efficiency particulate air (HEPA) filtration is specified in Section 234133 "High-Efficiency Particulate Air Filtration."

C. Panel Filters:

1. Description: Pleated, factory-fabricated, self-supported, disposable air filters with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive.
4. Filter-Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.

D. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.

E. Side-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized steel track.

a. Prefilters: Incorporate an integral 2-inch- thick track with same access as primary filter.
b. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.6 DAMPERS

A. Dampers: Comply with requirements in Section 230923.12 "Control Dampers."

B. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with zinc-replated steel operating rods rotating in stainless steel sleeve bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg, leakage Class 1, tested, rated, and labeled in accordance with AMCA 511.

C. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."

D. Electronic Damper Operators:
1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
3. Operator Motors:
a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
6. Size dampers for running torque calculated as follows:
a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft. of damper.

d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

7. Coupling: V-bolt and V-shaped, toothed cradle.
8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
10. Power Requirements (Two-Position Spring Return): Select signal voltage to in keeping with BAS system, refer to section 230923.
11. Power Requirements (Modulating): Select signal voltage to in keeping with BAS system, refer to section 230923.
12. Proportional Signal: Select signal voltage to in keeping with BAS system, refer to section 230923..
13. Temperature Rating: Minus 22 to plus 122 deg F.
14. Run Time: 15 seconds stroke.

E. Air flow station:

1. Thermal dispersion technology, velocity weighted averaging, temperature independent, factory installed integral to unit.
2. Provide with BAS connectivity in common BACnet MS-TP protocol per section 230923, complete communication to/from BAS, including temperature readings, status, rates, alarms.
3. Calibration range 0-3000 fpm, NIST. UL 60730 and RoHS2 compliant
4. Minimum 4% accuracy
5. Aluminum probe and stainless steel brackets, fasteners.
6. Ebtron or equal.

F. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.

2.7 ROOF CURBS

A. Provide curb, clips and fasteners as a system specifically suited for the unit to be installed, certified by qualified professional engineer, to attach unit and curb to roof structure for withstanding high wind conditions as required by the local authority having jurisdiction.

B. Roof curbs with wind restraints as required by local authority having jurisdiction, refer to section 230548 "Vibration and Seismic Controls for HVAC."

C. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

a. Materials: ASTM C1071, Type I or II.
b. Thickness: 1 inch.

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

a. Liner Adhesive: Comply with ASTM C916, Type I.
b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
c. Liner materials applied in this location to have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.

D. Curb Dimensions: Height of 12 inches.

2.8 INTAKE AND RELIEF AIR OPENINGS

A. Provide hood, including moisture eliminator, screens, over all unit intake and relief openings. Match material and finish of casing exterior.

2.9 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

2.10 ELECTRICAL POWER CONNECTIONS

A. Packaged outdoor air-handlers are to have a single connection of power to the unit with unit-mounted disconnect switch accessible from outside unit, and control-circuit transformer with built-in over-current protection.

2.11 CONTROLS

A. Control equipment shall fully communicate with, and comply with, requirement specified in Section 230923 "Direct Digital Control (DDC) System for HVAC", and operate per the control sequences defined in section 230993.11 for “Sequences of

Operation for HVAC DDC”.

B. Basic Unit Controls:

1. Factory installed, complete, integrated microprocessor-based DDC controller for unit.
2. Controller, interface, associated factory installed control devices capable of stand-alone operation.
3. Controller, interface and associated factory installed control devices shall utilize non-proprietary BACnet ASHRAE 135 communication protocol, requiring no keys or licenses (refer to section 230923)
4. Control-voltage transformer.
5. Key-pad interface and display panel:

   a. Configuration: Unit-mounted within control enclosure out of weather.
   b. Backlit LCD display screen and lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
   c. Capable of local password protection for access
   d. DDC controller shall interface with HVAC instrumentation and control system per section 230923.
   e. Digital display of all controls information, set-points, sensor readings, positions, modes, alarms; including but not limited to the following:

      1) outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.
      2) Fan speeds, return and outdoor enthalpy, hydronic modulating control valves positions, cooling and heating capacity.

C. Controller:

1. Type: DDC, interfaced to BAS specified in section 230923.
2. Controller to have volatile-memory backup.
3. Safety Control Operation:

   a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire-alarm control panel.
   b. Firestats: Stop fan and close outdoor-air damper if air greater than 130 deg F enters unit. Provide additional contacts for alarm interface to fire-alarm control panel.
   c. Fire-Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Division 28 specifications for "Addressable Fire-Alarm Systems."
   d. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply-air temperature is less than 40 deg F.
   e. Freeze-stat, factory positioned and wired directly to the unit controller terminations for protecting hydronic coils from low temperatures with potential to freeze coils, close outdoor air and relief air dampers, stop fans.

4. Scheduled Operation: provide from BAS, refer to 230923
5. Provide sequence of operation as defined in section 230993.11, refer to Section 230993.11, paragraph 1.6, for sequences of operation for air handling units.
6. Supply Fan Operation:
   a. Occupied Periods: Run fan continuously.
   b. Unoccupied Periods: Cycle fan to maintain setback temperature.
7. Cooling Operation:
   a. Occupied Periods: Constant supply fan operation, modulate chilled water control valve to supply air temperature setpoint upon calls for cooling and dehumidification.
   b. Unoccupied Periods: Cycle supply fan and modulate chilled water control valve to supply air temperature setpoint upon calls for cooling and dehumidification.
   c. Refer to section 230993, paragraph 1.6.
8. Heating Operation:
   a. Occupied Periods: Constant supply fan operation, modulate heating hot water control valve to supply air temperature setpoint upon call for preheat.
   b. Unoccupied Periods: Cycle supply fan and modulate heating hot water control valve to supply air temperature setpoint upon calls for preheating.
   c. Refer to section 230993, paragraph 1.6.
9. Economizer Outdoor-Air Damper Operation:
   a. Occupied Periods: Open to required ventilation minimum intake, and up to maximum 100 percent of the fan capacity. Controller is to permit air-side economizer operation when outdoor air is less than 60 deg F. Use outdoor-air enthalpy and differential between outdoor-air and return-air enthalpy to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper. During economizer cycle operation, lock out chilled water cooling.
   b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
   c. Outdoor-Airflow Monitor: Accuracy maximum plus or minus 4 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor to adjust for temperature.
      1) Thermal dispersion technology, velocity weighted averaging, temperature independent, factory installed integral to unit.
      2) Provide with BAS connectivity in common BACnet MS-TP protocol per section 230923, complete communication to/from BAS, including temperature readings, status, rates, alarms.
      3) Calibration range 0-3000 fpm, NIST. UL 60730 and RoHS2 compliant
      4) Minimum 4% accuracy
      5) Aluminum probe and stainless steel brackets, fasteners.

6) Ebtron or equal.

10. Terminal-Unit Integration:

    a. Provide heating- and cooling-mode changeover points compatible with terminal control system required in Section 233600 "Air Terminal Units" and Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Interface Requirements for HVAC Instrumentation and Control System:

1. Interface to/from BAS for scheduled operation.
2. Interface to/from BAS to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide BACnet compatible interface to/from the BAS of all controls information, set-points, sensor readings, positions, modes, alarms; including but not limited to the following:

    a. Adjusting set points.
    b. Monitoring supply fan and exhaust fan start, stop, and operation.
    c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity.
    d. Monitoring occupied and unoccupied operations.
    e. Monitoring constant and variable motor loads.
    f. Monitoring variable-frequency drive operation.
    g. Heating hot water control valve position
    h. Chilled water control valve position
    i. Monitoring cooling load.
    j. Monitoring economizer cycles.
    k. Monitoring air-distribution static pressure and ventilation air volume.
    l. All other listed in paragraph 1.6. section 230993.11 “Sequence of Operation for HVAC DDC”

4. Provide all points to BAS suitable for generation of color and alpha-numeric graphic display at the BAS operator workstation by the BAS software, refer to section 230923, paragraph 2.10.

2.12 SOURCE QUALITY CONTROL

A. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.

B. AHRI 1060 Certification: Test, rate, and label air-handling units that include air-to-air energy recovery devices in accordance with AHRI 1060.

C. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label in accordance with AHRI 260 or AMCA 311.

D. Fan Aerodynamic Performance Rating: Test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA

210.

E. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.

F. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

G. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION, GENERAL

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." Install airhandlers on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 7 specification. Secure airhandlers to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided..

B. Provide the services of a licensed rigging contractor for the installation of curb and units; coordinate with the Project Manager minimum 7 days in advance of scheduled lift(s).

C. Arrange installation of units to provide access space around air-handling units for service and maintenance.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

E. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

F. Connect duct following manufacturer’s recommendations

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow space for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange, strainer, at each coil supply connection. Install pressure independent control valve, and union or flange, at each coil return connection.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
7. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
8. Comb coil fins for parallel orientation.
9. Verify that proper thermal-overload protection is installed for electric coils.
10. Install new, clean filters.
11. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.7 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.9 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks.
2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Test control I/O as outlined in specification 230923, paragraph 3.23; coordinate schedule with the contractor for the BAS (Temperature Controls System).
5. Perform validation of unit controls outlined in specification 230923, paragraph 3.24; coordinate schedule with the contractor for the BAS (Temperature Controls System).
6. Air-handling unit and components will be considered defective if unit or components do not pass tests and inspections.
7. Prepare test and inspection reports.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to assist in training Owner's maintenance personnel to adjust, operate, and maintain air-handling units. Provide final review for units operation, followed by demonstration, as outlined in the specification 230923, paragraph 3.25; coordinate schedule with the contractor for the BAS (Temperature Controls System).

3.11 OCCUPANCY ADJUSTING

A. When requested within 12 months from date of completed validation testing; provide on-site assistance in adjusting units to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.12 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at completed validation testing, verify that service agreement includes software support for two year(s).

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two year(s) from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.

C. Updates to software necessary to correct any deficiencies are to be provided at no charge to the owner.

D. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

END OF SECTION 237343.16

SECTION 237416.11 – PACKAGED ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Packaged, small-capacity, rooftop air-conditioning units (RTUs) with the following components:

1. Unit casings.
2. Fans, drives, and motors.
3. Rotary heat exchanger.
4. Coils.
5. Refrigerant circuit components.
6. Air filtration.
7. Gas furnaces.
8. Dampers.
9. Electrical power connections.
10. Controls.
11. Roof curbs.
12. Accessories.

1.2 DEFINITIONS

A. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, small-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

B. BAS: Building Automation System, as defined in section 230923

1.3 ACTION SUBMITTALS

A. Product Data: For each RTU.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, dimensions, required clearances, characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
    a. Include certified fan-performance curves with system operating conditions indicated.
    b. Include certified fan-sound power ratings.
    c. Include fan construction and accessories.
    d. Include motor ratings, electrical characteristics, and motor accessories.

6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include gas furnaces with performance characteristics.
9. Include dampers, including housings, linkages, and operators.
10. Provide a complete list of all points data base for read/write to the BAS.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.

C. Shop Drawings: For each packaged, small-capacity, rooftop air-conditioning unit.

1. Include plans, elevations, sections, and mounting, attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Delegated Design Submittals: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators and high wind restraints, and for their design meeting requirements per ASCE/SEI 7.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Restraint Details: Wind-detail fabrication and attachment of wind restraints, brackets, steel and clips. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades. Refer to Section 230500.

B. Sample Warranty: For manufacturer's warranty.

C. Seismic Qualification Data: Certificates, for RTUs, 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.
4. Restraint of internal components.

D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force 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. Source quality-control reports.

F. System startup reports.

G. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of packaged, small-capacity, rooftop air-conditioning unit that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 2 year(s) from date of Substantial Completion.
2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion
3. Warranty Period for Compressors: Manufacturer's standard, but not less than 5 years from date of Substantial Completion

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE 15 Compliance: For refrigeration system safety.

E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. UL Compliance: Comply with UL 1995.

G. Delegated Design: Certification by a qualified professional engineer, as defined in Division 1 specification sections for Quality Requirements, for factory roof curb, clips and fasteners for high wind restraining of unit and curb.

1. Design RTU supports to comply with local wind and seismic performance requirements required by the Authority Having Jurisdiction.

2.2 PACKAGED, SMALL-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:

1. Daikin
2. Carrier
3. Engineered Air
4. Trane

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Double-Wall Construction:

1. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick with manufacturer's standard finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
2. Inside Casing Wall: G90-coated galvanized steel.
3. Floor Plate: G90 galvanized steel minimum 18 gauge thick.
4. Casing Insulation:

a. Materials: Injected polyurethane foam insulation.
b. Casing Panel R-Value: Minimum R-13.
c. Insulation Thickness: 2 inch.
d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.

C. Airstream Surfaces: Surfaces in contact with airstream to comply with requirements in ASHRAE 62.1.

D. Static-Pressure Classifications:

1. For Unit Sections Upstream of Fans: Minus 4-inch wg.
2. For Unit Sections Downstream and Including Fans: 4-inch wg.

E. Panels and Doors:

1. Panels:

    a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
    b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement to allow panels to be opened against air-pressure differential.
    c. Gasket: Neoprene, applied around entire perimeters of panel frames.
    d. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

2. Access Doors:

    a. Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
    b. Gasket: Neoprene, applied around entire perimeters of panel frames.
    c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Locations:

    a. Fan Section.
    b. Access Section
    c. Coil Section.
    d. Damper Section.
    e. Filter Section.
    f. Furnace/Burner
    g. Mixing Section
    h. Relief-Return fans
    i. Controls

F. Condensate Drain Pans:

1. Location: Each type of cooling coil.
2. Construction:

    a. Single-wall, stainless steel sheet.

3. Drain Connection:

    a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
    b. Minimum Connection Size: NPS 3/4.

4. Slope: Minimum to comply with ASHRAE 62.1, to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends).
5. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
6. Width: Entire width of water producing device.
7. Depth: A minimum of 2 inches deep.
8. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
9. Units with stacked coils must have an intermediate drain pan to collect condensate from top coil.

2.4 FANS, DRIVES, AND MOTORS

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower. Capable of modulation down to 30% of design flow with no surge.

B. Supply-Air Fans: Centrifugal, airfoil, rated according to AMCA 210; galvanized or painted steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.
   a. Turned, ground, and polished hot-rolled steel with keyway.
2. Shaft Bearings:
   a. Heavy-duty, self-aligning, pillow-block type with an L-50 bearing life rating of minimum 100,000 hours according to ABMA 9.
3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
   a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
4. Centrifugal Fan Wheels: (Plenum Fan Wheels) smooth curved inlet flange, backplate, and hollow die-formed airfoil shaped blades, continuously welded at tip flange and backplate, steel or aluminum hub riveted to backplate and fastened to shaft with setscrews.
5. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
6. Flexible Connector: Factory fabricated to limit transmittal of vibration to ductwork, building.

C. Drives, Direct: Factory-mounted, direct drive.

D. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated ECM motors.

E. Relief-Air Fan: SWSI air foil, shaft mounted on permanently lubricated motor.

F. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Enclosure Type: Totally enclosed, fan cooled ECM motors.
4. Efficiency: Premium efficient as defined in NEMA MG 1.
5. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
6. Mount the unit-mounted disconnect protected from weather
7. Variable-Frequency Motor Controller: Serving each fan individually.

    a. Manufactured Units: Pulse-width modulated; constant torque, and variable torque for inverter-duty motors.
    b. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range, 66 Hz. maximum voltage equals input voltage.
    c. Mounted outside airstream, protected from weather, in controls cabinet with hinged access door.
    d. Meet UL Standard 95-5V
    e. Unit Operating Requirements:

        1) Internal Adjustability:

            a) Minimum Speed: 5 to 25 percent of maximum rpm.
            b) Maximum Speed: 80 to 100 percent of maximum rpm.
            c) Acceleration: 0.1 to 999.9 seconds.
            d) Deceleration:0.1 to 999.9 seconds.
            e) Current Limit: 30 to minimum of 150 percent of maximum rating.

        2) Self-Protection and Reliability Features:

            a) Surge suppression.
            b) Loss of input signal protection.
            c) Under- and overvoltage trips.
            d) Variable-frequency motor controller and motor-overload/overtemperature protection.
            e) Critical frequency rejection.
            f) Loss-of-phase protection.
            g) Reverse-phase protection.
            h) Motor-overtemperature fault.

        3) Bidirectional autospeed search.
        4) Torque boost.
        5) Motor temperature compensation at slow speeds.

            a) Panel-mounted operator station.
            b) Historical logging information and displays.

c) Digital indicating devices.

6) Control Signal Interface: Electric.
7) Proportional Integral Directive (PID) control interface.
8) DDC system for HVAC Protocols for Network Communications: ASHRAE 135, fully communicating with the BAS, refer to section 230293.

f. Line Conditioning:

1) Input line conditioning.
2) Output filtering.
3) EMI/RFI filtering.

8. Comply with Section 232923 "Variable-Frequency Motor Controllers."

2.5 COILS

A. General Requirements for Coils:

1. Comply with AHRI 410.
2. Fabricate coils section to allow for removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils to not act as structural component of unit.

B. Supply-Air Refrigerant Coil:

1. Tubes: Copper, interlaced.
2. Fins: Aluminum
3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections
5. Frames: Galvanized steel.
6. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

a. Working Pressure: Minimum 300 psig.

2.6 REFRIGERANT CIRCUIT COMPONENTS

A. Compressors: Two Hermetic, scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

B. Refrigeration Specialties:

1. Refrigerant: R-410A.
2. Expansion valves with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.

8. Brass service valves installed in compressor suction and liquid lines.
9. Inverter compressor providing proportional control
10. Low head pressure control bypass refrigerant valve between suction and discharge.

2.7 AIR FILTRATION

A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

B. Panel Filters:

1. Description: Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
4. Filter-Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.

C. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.

D. Adhesive, LEED for Schools Projects: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.8 GAS FURNACES

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.

B. CSA Approval: Designed and certified by and bearing label of CSA.

C. Burners: Stainless steel.

1. Rated Minimum Turndown Ratio: 10 to 1.
2. Fuel: Natural gas.
3. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
4. Gas Control Valve: Modulating.
5. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

D. Heat-Exchanger and Drain Pan: Stainless steel.

E. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve with extension.

F. Safety Controls:

1. Gas Manifold: Safety switches and controls complying with ANSI standards FM Global. Two flame roll-out safety switches and high temperature limit switch.

2.9 DAMPERS

A. Comply with requirements in Section 230923.12 "Control Dampers."

B. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate must not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg rated in accordance with AMCA 500D.

C. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."

D. Electronic Damper Operators:

1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator to have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
3. Operator Motors:
   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
   c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
6. Size dampers for running torque calculated as follows:
   a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
   b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
   c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.

d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

7. Coupling: V-bolt and V-shaped, toothed cradle.
8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
10. Refer to 230923 and 230993.11 specifications for required BacNet communication, signal types, operating sequences.
11. Temperature Rating: Minus 22 to plus 122 deg F.

2.10 ELECTRICAL POWER CONNECTIONS

A. RTU to have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.11 CONTROLS

A. Control equipment shall fully communicate with, and comply with, requirement specified in Section 230923 "Direct Digital Control (DDC) System for HVAC", and operate per the control sequences defined in section 230993.11 for “Sequences of Operation for HVAC DDC”.

B. Basic Unit Controls:

1. Factory installed, complete, integrated microprocessor-based DDC controller for unit.
2. Controller, interface, associated factory installed control devices capable of stand-alone operation.
3. Controller, interface and associated factory installed control devices shall utilize non-proprietary BACnet ASHRAE 135 communication protocol, requiring no keys or licenses (refer to section 230923)
4. Control-voltage transformer.
5. Key-pad interface and display panel:

a. Configuration: Unit-mounted within control enclosure out of weather.
b. Backlit LCD display screen and lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
c. Capable of local password protection for access
d. DDC controller shall interface with HVAC instrumentation and control system per section 230923.
e. Digital display of all controls information, set-points, sensor readings, positions, modes, alarms; including but not limited to the following:

1) outdoor-air temperature, supply-air temperature, return-air

temperature, economizer damper position, indoor-air quality, and control parameters.

2) Fan speeds, return and outdoor enthalpy, furnace gas valve modulation and capacity, compressor stages and capacity.

C. Controller:

1. Type: DDC, interfaced to BAS specified in section 230923.
2. Controller to have volatile-memory backup.
3. Safety Control Operation:

   a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire-alarm control panel.
   b. Firestats: Stop fan and close outdoor-air damper if air greater than 130 deg F enters unit. Provide additional contacts for alarm interface to fire-alarm control panel.
   c. Fire-Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Division 28 specifications for "Addressable Fire-Alarm Systems."
   d. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply-air temperature is less than 40 deg F.

4. Scheduled Operation: provide from BAS, refer to 230923
5. Provide sequence of operation as defined in section 230993.11, refer to Section 230993.11, paragraph 1.6, for sequences of operation for air handling units.
6. Supply Fan Operation:

   a. Occupied Periods: Run fan continuously.
   b. Unoccupied Periods: Cycle fan to maintain setback temperature.

7. Refrigerant Circuit Operation:

   a. Occupied Periods: Cycle or stage compressors, and operate hot-gas bypass to match compressor output to cooling load to maintain discharge temperature and humidity. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
   b. Unoccupied Periods: Cycle compressors and condenser fans for heating to maintain setback temperature.

8. Furnace Operation:

   a. Occupied Periods: Cycle through modulation of gas valve furnace heating to match output to heating load for maintaining discharge temperature..
   b. Unoccupied Periods: Cycle heating for heating to maintain setback temperature.

9. Economizer Outdoor-Air Damper Operation:

   a. Occupied Periods: Open to required ventilation minimum intake, and up to maximum 100 percent of the fan capacity. Controller is to permit air-side economizer operation when outdoor air is less than 60 deg F. Use outdoor-air enthalpy and differential between outdoor-air and return-air enthalpy to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper. During economizer cycle operation, lock out cooling.

b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

c. Outdoor-Airflow Monitor: Accuracy maximum plus or minus 4 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor to adjust for temperature.

1) Thermal dispersion technology, velocity weighted averaging, temperature independent, factory installed integral to unit.
2) Provide with BAS connectivity in common BACnet MS-TP protocol per section 230923, complete communication to/from BAS, including temperature readings, status, rates, alarms.
3) Calibration range 0-3000 fpm, NIST. UL 60730 and RoHS2 compliant
4) Minimum 4% accuracy
5) Aluminum probe and stainless steel brackets, fasteners.
6) Ebtron or equal.

10. Terminal-Unit Integration:

a. Provide heating- and cooling-mode changeover points compatible with terminal control system required in Section 233600 "Air Terminal Units" and Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Interface Requirements for HVAC Instrumentation and Control System:

1. Interface to/from BAS for scheduled operation.
2. Interface to/from BAS to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide BACnet compatible interface to/from the BAS of all controls information, set-points, sensor readings, positions, modes, alarms; including but not limited to the following::

a. Adjusting set points.
b. Monitoring supply fan and exhaust fan start, stop, and operation.
c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity.
d. Monitoring occupied and unoccupied operations.
e. Monitoring constant and variable motor loads.
f. Monitoring variable-frequency drive operation.
g. Furnaces operation, percent full fire.
h. Monitoring cooling load.
i. Monitoring economizer cycles.
j. Monitoring air-distribution static pressure and ventilation air volume.
k. All other listed in paragraph 1.6. section 230993.11 “Sequence of Operation

for HVAC DDC"

4. Provide all points to BAS suitable for generation of color and alpha-numeric graphic display at the BAS operator workstation by the BAS software, refer to section 230923, paragraph 2.10.

2.12 ROOF CURBS

A. Provide curb, clips and fasteners as a system specifically suited for the unit to be installed, certified by qualified professional engineer, to attach unit and curb to roof structure for withstanding high wind conditions as required by the local authority having jurisdiction.

B. Roof curbs with wind restraints as required by local authority having jurisdiction, refer to section 230548 "Vibration and Seismic Controls for HVAC."

C. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

   a. Materials: ASTM C1071, Type I or II.
   b. Thickness: 1 inch.

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

   a. Liner Adhesive: Comply with ASTM C916, Type I.
   b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
   c. Liner materials applied in this location to have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.

D. Curb Dimensions: Height of 12 inches.

2.13 ACCESSORIES

A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet is to be energized even if the unit main disconnect is open.

B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

C. Remote potentiometer to adjust minimum economizer damper position.

D. Safeties:

1. Smoke detector.
2. Condensate overflow switch.
3. Phase-loss reversal protection.
4. High and low pressure control.
5. Gas furnace airflow-proving switch.

E. Coil guards of painted, galvanized-steel wire.

F. Hail guards of galvanized steel, painted to match casing.

G. Outdoor-air intake weather hood with moisture eliminator, screens.

2.14 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B117.

1. Standards:

a. ASTM B117 for salt spray.
b. ASTM D2794 for minimum impact resistance of 100 in-lb.
c. ASTM B3359 for cross-hatch adhesion of 5B.

2. Application: Spray.
3. Thickness: 1 mil
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.15 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.
2. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.

3. Comply with AHRI 270 for testing and rating sound performance for RTUs.
4. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

B. AMCA Compliance:

1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested according to AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

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 RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

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

3.2 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 7 specification. Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.

B. Provide the services of a licensed rigging contractor for the installation of curb and units; coordinate with the Project Manager minimum 7 days in advance of scheduled lift(s).

C. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to RTU, allow space for service and maintenance.

C. Connect piping to unit mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4 ASTM B88, Type M copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Gas Piping: Comply with applicable requirements in Section 221123 "Facility Natural-Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

3.4 DUCT CONNECTIONS

A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
4. Install return-air duct continuously through roof structure.

3.5 ELECTRICAL CONNECTIONS

A. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate is to be laminated acrylic or melamine plastic signs as specified in Division 26 specification sections for "Identification for Electrical Systems."
2. Nameplate is to be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least 1/2 inch high.
3. Locate nameplate where easily visible.

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Division 26 specifications for "Control-Voltage Electrical Power Cables."

3.7 STARTUP SERVICE

A. Engage a factory-authorized service technician to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Inspect for visible damage to unit casing.
3. Inspect for visible damage to furnace combustion chamber.
4. Inspect for visible damage to compressor, coils, and fans.
5. Inspect internal insulation.
6. Verify that labels are clearly visible.
7. Verify that clearances have been provided for servicing.
8. Verify that controls are connected and operable.
9. Verify that filters are installed.
10. Clean condenser coil and inspect for construction debris.
11. Clean furnace flue and inspect for construction debris.
12. Connect and purge gas line.
13. Remove packing from vibration isolators.
14. Inspect operation of relief dampers.
15. Verify lubrication on fan and motor bearings.
16. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
17. Adjust fan belts to proper alignment and tension.
18. Start unit according to manufacturer's written instructions.
    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.
19. Inspect and record performance of interlocks and protective devices; verify sequences.
20. Operate unit for an initial period as recommended or required by manufacturer.
21. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency:
    a. Measure gas pressure on manifold.
    b. Inspect operation of power vents.
    c. Measure combustion-air temperature at inlet to combustion chamber.
    d. Measure flue-gas temperature at furnace discharge.
    e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
22. Calibrate thermostats.
23. Adjust and inspect high-temperature limits.

24. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
25. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:
    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
26. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
27. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
    a. Supply-air volume.
    b. Return-air volume.
    c. Relief-air volume.
    d. Outdoor-air intake volume.
28. Simulate maximum cooling demand and inspect the following:
    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
29. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
    a. High-temperature limit on gas-fired heat exchanger.
    b. Low-temperature safety operation.
    c. Filter high-pressure differential alarm.
    d. Economizer to minimum outdoor-air changeover.
    e. Relief-air fan operation.
    f. Smoke and firestat alarms.
30. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.8 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.9 CLEANING

A. After completing system installation and testing, adjusting, and balancing RTUs and air-distribution systems, clean RTUs internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:
1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Test control I/O as outlined in specification 230923, paragraph 3.23; coordinate schedule with the contractor for the BAS (Temperature Controls System).
6. Perform validation of unit controls outlined in specification 230923, paragraph 3.24; coordinate schedule with the contractor for the BAS (Temperature Controls System).
7. RTU will be considered defective if it does not pass tests and inspections.
8. Prepare test and inspection reports.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain RTUs. Provide final review for units operation, followed by demonstration, as outlined in the specification 230923, paragraph 3.25; coordinate schedule with the contractor for the BAS (Temperature Controls System).

3.12 OCCUPANCY ADJUSTING

A. When requested within 12 months from date of completed validation testing; provide on-site assistance in adjusting units to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.13 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at completed validation testing, verify that service agreement includes software support for two year(s).

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two year(s) from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.

C. Updates to software necessary to correct any deficiencies are to be provided at no charge to the owner.

D. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

END OF SECTION 237416.11

SECTION 238126 – DUCTLESS SPLIT-SYSTEM HEAT PUMPS

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: 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 units with factory-applied color finishes.

1.2 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.5 COORDINATION

A. Coordinate sizes and locations of equipment supports, and wall penetrations with actual equipment provided.

B. Refer to Section 230500 for Coordination drawings

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressor: Five year(s) from date of Substantial Completion.
b. For Parts: Two year(s) from date of Substantial Completion.
c. For Labor: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SPLIT-SYSTEM AIR-CONDITIONERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:

1. Daikin
2. Mitsubishi Electric & Electronics USA, Inc.
3. Samsung HVAC
4. SANYO North America Corporation
5. Carrier

2.2 INDOOR UNITS

A. Wall-Mounted, Evaporator-Fan Components:

1. Cabinet: steel base and removable HDPE front and ends in factor standard color, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
3. Fan: Direct drive, centrifugal.
4. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. ECM variable speed with internal thermal protection and permanent lubrication.

c. Enclosure Type: Totally enclosed, fan cooled.
d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
f. Mount unit-mounted disconnect switches on exterior of unit.

5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
6. Condensate Drain Pans:

a. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.

1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
2) Depth: A minimum of 1 inch deep.

b. Single-wall, galvanized steel sheet with foam insulation and moisture-tight seal.
c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

1) Minimum Connection Size: NPS 5/8.

d. Pan-Top Surface Coating: Asphaltic waterproofing compound.

7. Air Filtration Section:

a. General Requirements for Air Filtration Section:

1) Comply with NFPA 90A. Washable media.
2) Minimum MERV according to ASHRAE 52.2.
3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

2.3 OUTDOOR UNITS

A. Air-Cooled, Compressor-Condenser Heat Pump:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

a. Compressor Type: Scroll.
b. Variable-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.

c. Refrigerant: R-410A.
d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

3. Heat-Pump Components: Reversing valve.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 0 deg F.
7. Mounting Base: wall bracket

2.4 ACCESSORIES

A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Thermostat:

1. Low voltage with subbase to control compressor and evaporator fan.
2. Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:

a. Compressor time delay.
b. 24-hour time control of system stop and start.
c. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
d. Fan-speed selection including auto setting.

C. Automatic-reset timer to prevent rapid cycling of compressor.

D. Factory field settings and wind baffle to assure low-ambient operation to 5 F outdoors.

E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

F. Condensate drainage pump: Factory provided float operated condensate removal pump, barbed outlet, minimum 10 ft WC lift capacity, integral alarms and contacts to shut off compressor and alert BAS in the event of failure to remove condensate.

G. Wall support bracket: Factory designed and fabricated of heavy galvanized steel for selected unit; powder-coated paint finish, pre-drilled with fasteners and hardware for securing bracket to wall, and heat pump to bracket.

H. Monitoring:

1. Monitor cooling and heating modes
2. All alarms
3. Space temperature.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting bracket, plates, devices securely fastened to building structure.

C. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Install and connect pre-charged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit. Route to minimize the amount of the refrigerant piping exposed outdoors.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Provide condensate drainage piping with field applied insulation and vapor barrier to prevent condensation, discharge to mop basin in other room.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service Assistance: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to assist in startup service.

1. Complete installation and startup checks according to manufacturer's written instructions, using manufacturer report forms.
2. Operate and test all control functions, including condensate pump and alarms.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 238126

COMPLETE RENOVATION/MECHANICAL UPGRADES FOR:

GREENE COUNTY PUBLIC LIBRARY
XENIA COMMUNITY LIBRARY

76 EAST MARKET ST.

XENIA, OH 45385

ABBREVIATION INDEX

&	AND	F.R.T.	FIRE RATED TREATED	P.V.C.	POLY VINYL CHLORIDE
@	AT	FT.	FOOT	Q.A.	QUARRY TILE
A/C	AIR CONDITIONING	FURN.	FURNITURE	QTY.	QUANTITY
A.D.	AREA DRAIN	GA.	GAUGE	R.A.	REGISTERED ARCHITECT
A.F.F.	ABOVE FINISH FLOOR	GALV.	GALVANIZED	RAD.	RADIUS
ALUM.	ALUMINUM	GYP. BD.	GYPSUM BOARD	REF.	REFRIGERATOR
ALT.	ALTERNATE	HDWD.	HARDWOOD	REINF.	REINFORCING
APPROX.	APPROXIMATE	HDR.	HEADER	REV.	REVISION
B/	BOTTOM OF	H.M.	HOLLOW METAL	REQ'D	REQUIRED
BD.	BOARD	HORIZ.	HORIZONTAL	RESIL.	RESILIENT
BLDG.	BUILDING	HGT.	HEIGHT	RM.	ROOM
BM.	BEAM	I.D.	INSIDE DIAMETER	R.O.	ROUGH OPENING
BSMT.	BASEMENT	INSUL.	INSULATION	SCHED.	SCHEDULE
BTWN.	BETWEEN	INT.	INTERIOR	SEC.	SECTION
BOT.	BOTTOM	JT.	JOINT	S.F.	SQUARE FOOT
C.L.	CENTER LINE	KIT.	KITCHEN	SHT.	SHEET
C.T.	CERAMIC TILE	LAM.	LAMINATE	SIM.	SIMILAR
CLG.	CEILING	LAV.	LAVATORY	SPEC.	SPECIFICATION
CLOS.	CLOSET	LT.	LIGHT	SQ.	SQUARE
CM	CONSTRUCTION MGR.	MAS.	MASONRY	S.S.	STAINLESS STEEL
CMU	CONC. MASONRY UNIT	MAX.	MAXIMUM	STD.	STANDARD
COL.	COLUMN	MECH.	MECHANICAL	STL.	STEEL
CONC.	CONCRETE	MTL.	METAL	STRUCT.	STRUCTURAL
CONT.	CONTINUOUS	MFR.	MANUFACTURER	SUSP.	SUSPENDED
CONST.	CONSTRUCTION	MIN.	MINIMUM	T/	TOP OF
DEPT.	DEPARTMENT	MISC.	MISCELLANEOUS	TEL.	TELEPHONE
DTL.	DETAIL	M.O.	MASONRY OPENING	THK.	THICK
D.F.	DRINKING FOUNTAIN	MTD.	MOUNTED	THRU	THROUGH
DIA.	DIAMETER	N.I.C.	NOT IN CONTRACT	T.O.P.	TOP OF PLATE
DIM.	DIMENSION	NO.	NUMBER	T.O.S.	TOP OF STEEL
DISP.	DISPENSER	NOM.	NOMINAL	T.O.SL.	TOP OF SLAB
DN.	DOWN	N.T.S.	NOT TO SCALE	TRT.	TREATED
DR.	DOOR	O.A.	OVERALL	TYP.	TYPICAL
D.S.	DOWN SPOUT	O.C.	ON CENTER	V.C.B.	VINYL COMPOSITION BASE
DWG.	DRAWING	O.D.	OUTSIDE DIAMETER	V.C.T.	VINYL COMPOSITION TILE
EA.	EACH	OPNG.	OPENING	VERT.	VERTICAL
EL.	ELEVATION	OPP.	OPPOSITE	V.I.F.	VERIFY IN FIELD
ELEC.	ELECTRICAL	OPT.	OPTIONAL	V.W.C.	VINYL WALL COVERING
EQ.	EQUAL	PL.	PLATE	W/	WITH
EQUIP.	EQUIPMENT	P.LAM.	PLASTIC LAMINATE	W.C.	WATER CLOSET
EXIST.	EXISTING	PLUMB.	PLUMBING	WD.	WOOD
EXT.	EXTERIOR	PLYWD.	PLYWOOD	W/O	WITHOUT
EWC	ELECTRIC WATER COOLER	PR.	PAIR	WP.	WATERPROOFING
F.D.	FLOOR DRAIN	PROP.	PROPERTY	WT.	WEIGHT
FIN.	FINISH	P.S.F.	PER SQUARE FOOT	WWM.	WELDED WIRE MESH
FL.	FLOOR	P.S.I.	PER SQUARE INCH		
F.O.	FACE OF	PTD.	PAINTED		

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Enhanse

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GENERAL NOTES

1. THE USE OF THESE DOCUMENTS IS RESTRICTED TO THE ORIGINAL SITE FOR WHICH THEY WERE PREPARED. REUSE OR REPRODUCTION OF THE DOCUMENTS (WHOLE OR IN PART) FOR ANY OTHER PURPOSE IS PROHIBITED. K4 ARCHITECTURE, LLC. RETAINS ALL RIGHTS OF OWNERSHIP FOR THESE DOCUMENTS.
2. THE CONTRACTOR AND SUBCONTRACTORS SHALL BE SOLELY RESPONSIBLE FOR COMPLYING WITH ALL FEDERAL, STATE, AND LOCAL SAFETY REQUIREMENTS TOGETHER WITH EXERCISING PRECAUTIONS AT ALL TIMES FOR THE PROTECTION OF PERSONS INCLUDING EMPLOYEES AND PROPERTY. IT IS THE SOLE RESPONSIBILITY OF THE CONTRACTOR AND SUBCONTRACTORS TO INITIATE, MAINTAIN, AND SUPERVISE ALL SAFETY REQUIREMENTS, PRECAUTIONS, AND PROGRAMS IN CONNECTION WITH THE WORK.
3. THE GENERAL CONTRACTOR SHALL BE RESPONSIBLE TO COORDINATE ALL WORK AND FOR THE MEANS, METHODS, PROCEDURES, TECHNIQUES, AND SEQUENCE OF CONSTRUCTION.
4. THE GENERAL CONTRACTOR IS TO GUARANTEE ALL WORK INCLUDING WORK DONE BY SUBCONTRACTORS FOR A PERIOD OF ONE (1) YEAR COMMENCING WITH THE DATE OF SUBSTANTIAL COMPLETION.
5. GENERAL CONTRACTOR SHALL BE RESPONSIBLE FOR ALL SCHEDULING OF INSPECTIONS.
6. WHEN CONTRACTOR ACCEPTS DELIVERY OF ALL ITEMS NOTED ON PLANS EITHER IN CONTRACT OR NOT IN CONTRACT THEY SHALL BE RESPONSIBLE FOR LOSS AND/OR DAMAGE TO THESE ITEMS.
7. GENERAL CONTRACTOR TO HAVE JOB TRAILER AND PHONE ON PREMISES DURING ENTIRE CONSTRUCTION PERIOD.
8. THE GENERAL CONTRACTOR IS TO HAVE A FULL TIME QUALIFIED SUPERVISOR ON THE SITE AT ALL TIMES WHILE WORK IS BEING PERFORMED.
9. ALL DIMENSIONS SHOWN ARE NOMINAL DIMENSIONS UNLESS SPECIFICALLY NOTED OTHERWISE. THE GENERAL CONTRACTOR IS TO VERIFY ALL DIMENSIONS AND EXISTING FIELD CONDITIONS WITH THE DRAWINGS. IN PARTICULAR OVERALL WALL DIMENSIONS, SOIL CONDITIONS, INCOMING UTILITIES, ETC. GENERAL CONTRACTOR IS TO REPORT IMMEDIATELY TO THE ARCHITECT ANY VARIANCES OR FIELD CONDITIONS THAT MAY CAUSE CONSTRUCTION PROBLEMS PRIOR TO COMMENCING WORK.
10. DO NOT SCALE DRAWINGS. WRITTEN DIMENSIONS GOVERN. ALL PARTITION LOCATIONS, ALL DOOR AND OPENING LOCATIONS SHALL BE SHOWN ON FLOOR PLAN. IN CASE OF CONFLICT, NOTIFY THE ARCHITECT. FLOOR PLAN BY ARCHITECT SUPERCEDES ALL OTHER PLANS. ALL DIMENSIONS MARKED "CLEAR" OR "MIN." SHALL BE MAINTAINED AND SHALL ALLOW FOR THICKNESS OF ALL FINISHES INCLUDING CARPET, PAD, CERAMIC TILE, V.C.T., SLATWALL, ETC.
11. ALL DIMENSIONS SHOWN ARE TO FACE OF BLOCK OR FRAMING UNLESS SPECIFICALLY NOTED OTHERWISE.
12. PROVIDE PORTABLE FIRE EXTINGUISHERS WITH U.L. LABEL AND A RATING OF NOT LESS THAN 10lb-ABC WITH 75 FT TRAVEL DISTANCE TO ALL POSITIONS OF BUILDING OR AS DIRECTED BY THE FIRE DEPARTMENT FIELD INSPECTOR.
13. FIRE BLOCKING AT CONCEALED WALL SPACES. FIRE BLOCKING SHALL BE INSTALLED IN CONCEALED SPACES OF STUD WALLS AND PARTITIONS, INCLUDING FURRED OR STUDDED-OFF SPACES OF MASONRY OR CONCRETE WALLS, AND AT THE CEILING AND FLOOR OR ROOF LEVELS.
14. CONNECTIONS BETWEEN HORIZONTAL AND VERTICAL SPACES. FIRE BLOCKING SHALL BE INSTALLED AT ALL INTERCONNECTIONS BETWEEN VERTICAL AND HORIZONTAL SPACES SUCH AS OCCUR AT SOFFITS OVER CABINETS, DROP CEILINGS, COVE CEILINGS, AND SIMILAR LOCATIONS.
15. REQUIRED FLAME SPREAD RATING: INTERIOR FINISH OF WALLS AND CEILINGS SHALL HAVE A FLAME SPREAD RATING NOT GREATER THAN THAT DESIGNATED BY THE CLASS PRESCRIBED FOR THE VARIOUS GROUPS LISTED IN TABLE 803.4, WHEN TESTED IN ACCORDANCE WITH ASTM E-84.
16. ALL WOOD INSTALLED IN LOCATIONS IN CONTACT WITH MOISTURE TO BE PRESERVATIVE TREATED PER AWPA C1, C2, AND C9.
17. ALL GLASS UNITS LOCATED IN HAZARDOUS LOCATIONS SHALL COMPLY WITH TEST REQUIREMENTS OF CONSUMER PRODUCT SAFETY COMMISSION 16. CFR, PART 1201, FOR HUMAN IMPACT LOADS.
18. DOOR HARDWARE ON EGRESS DOORS SHALL ALLOW FOR EGRESS AT ALL TIMES WITHOUT THE USE OF A KEY OR SPECIAL KNOWLEDGE. ALL DOOR OPERATING DEVICES SHALL COMPLY WITH ADA AND BE OF LEVER DESIGN. SEE DOOR SCHEDULE FOR SPECIFIC DOOR HARDWARE FUNCTIONS.
19. ARCHITECT HIGHLY RECOMMENDS A PROFESSIONAL CAULKING CONTRACTOR THAT IS AUTHORIZED TO INSTALL ALL INTERIOR & EXTERIOR CAULKING / SEALANTS ON THIS PROJECT.
20. GENERAL CONTRACTOR & ALL SUBCONTRACTORS MUST REFER TO BOTH THE DRAWINGS & SPECIFICATIONS FOR THE COMPLETE SCOPE OF WORK. IT IS THE RESPONSIBILITY OF THE GENERAL CONTRACTOR & ALL SUBCONTRACTORS TO REVIEW THE COMPLETE SET OF DRAWINGS (SEE INDEX OF DRAWINGS, THIS SHEET) FOR SCOPE OF WORK AND QUANTITY OF MATERIAL.
21. INSTALLATION OF ALL MATERIAL SPECIFIED SHALL COMPLY WITH MANUFACTURE'S PRODUCT DATA, INCLUDING PRODUCT TECHNICAL BULLETINS, PRODUCT CATALOG INSTALLATION INSTRUCTIONS, PRODUCT CARTON INSTRUCTIONS, AND SPECIFICATIONS FOR HANDLING, STORAGE, INSTALLATION, AND CLEANING.
22. THE CONTRACTOR SHALL EVALUATE THE JOB SITE SAFETY THEREOF AND SHALL BE FULLY AND SOLELY RESPONSIBLE FOR THE JOB SITE SAFETY OF SUCH MEANS, METHODS, TECHNIQUES, SEQUENCES OR PROCEDURES.
23. CONTRACT DOCUMENTS ARE COMPLEMENTARY, AND WHAT IS REQUIRED BY ONE SHALL BE AS BINDING AS IF REQUIRED BY ALL.
24. BEFORE STARTING EACH PORTION OF THE WORK, THE CONTRACTOR SHALL CAREFULLY STUDY AND COMPARE THE VARIOUS DRAWINGS AND OTHER CONTRACT DOCUMENTS RELATIVE TO THAT PORTION OF THE WORK, SHALL TAKE FIELD MEASUREMENTS OF ANY EXISTING CONDITIONS RELATED TO THAT PORTION OF THE WORK AND SHALL OBSERVE ANY EXISTING CONDITIONS AT THE SITE AFFECTING IT. ANY ERRORS, INCONSISTENCIES OR OMISSIONS AND CONFLICTS DISCOVERED BY THE CONTRACTOR SHALL BE REPORTED PROMPTLY TO THE ARCHITECT AS A REQUEST FOR INFORMATION IN SUCH FORM AS THE ARCHITECT MAY REQUIRE FOR ARCHITECT'S RESOLUTION.
25. THE FURNISHINGS CONTRACT FOR THE ITEMS LISTED BELOW IS BY OTHERS. THE GENERAL CONTRACTOR SHALL NOT INCLUDE THESE MATERIALS OR INSTALLATION OF THESE ITEMS IN THEIR BID EXCEPT WHERE NOTED: FURNITURE, ARTWORK, GRAPHICS, INTERIOR DESIGN SERVICES
26. THE INTERIOR DESIGNER OR ARCHITECT WILL PROVIDE MATERIAL AND COLOR SELECTIONS FOR THE INTERIOR AND EXTERIOR FINISHES. THE MATERIAL AND INSTALLATION OF FINISHES IS BY THE GENERAL CONTRACTOR.
27. GENERAL CONTRACTOR IS RESPONSIBLE FOR CAULKING ALL CASEWORK AND BACKSPLASHES TO THE WALL.
28. THE DEMOLITION DRAWINGS AND ANY DRAWINGS ASSOCIATED WITH THE EXISTING BUILDING ARE INTENDED TO SHOW EXISTING CONDITIONS. EXISTING ARCHITECTURAL INFORMATION SHOWN WAS OBTAINED FROM EXISTING DRAWINGS BY K4 ARCHITECTURE, L.L.C (DATED 1976, 1990, 2000) AND CASUAL SITE VISITS. IN THE EVENT OF DISCREPANCY BETWEEN DRAWINGS AND ACTUAL, NOTIFY ARCHITECT IMMEDIATELY. DO NOT PROCEED WITH DEMOLITION OR CONSTRUCTION IN AREAS OF DISCREPANCY UNTIL ALL SUCH DISCREPANCIES HAVE BEEN RESOLVED.

GRAPHIC SYMBOLS

SECTION — SECTION NUMBER (1), SHEET NUMBER (A201)

DRAWING NOTES (1)

DOOR — DOOR NUMBER (101)

WINDOW — WINDOW MARK (A)

ROOM — ROOM NAME, ROOM NUMBER (101)

DETAIL — DETAIL NUMBER (1), SHEET NUMBER (A403)

PARTITION TYPES — PARTITION KEY (A)

COLUMN REFERENCE GRIDS (A)

INTERIOR ELEVATION INDICATOR (1, 2, 3, 4, A601 OR 1, A201)

INDEX OF DRAWINGS

SHEET	DESCRIPTION	BID ISSUE - 01/04/23	ADDENDUM B - 01/20/23	ADDENDUM C - 01/27/23
T001	TITLE SHEET	●	●	●
PHASING DRAWINGS				
PH001	PHASING LIFE SAFETY PLAN	●	●	
PH002	PHASING DEMO FLOOR PLAN & RCP	●	●	
PH003	PHASING FLOOR PLAN & RCP	●	●	
LIFE SAFETY DRAWINGS				
LS101	FIRST FLOOR LIFE SAFETY PLAN AND CODE INFORMATION	●	●	
LS102	SECOND FLOOR LIFE SAFETY PLAN AND CODE INFORMATION	●	●	
CIVIL DRAWINGS				
C100	DETAILS/NOTES	●		
C200	EX. CONDITIONS/DEMOLITION PLAN	●		
C300	GRADING PLAN	●		
C400	LAYOUT PLAN	●		
STRUCTURAL DRAWINGS				
S001	GENERAL STRUCTURAL NOTES	●		
S002	GENERAL STRUCTURAL NOTES	●		
S110	FOUNDATION PLAN	●	●	
S120	SECOND FLOOR FRAMING PLAN	●	●	
S130	ROOF FRAMING PLAN	●	●	
S310	FOUNDATION SECTIONS	●	●	
S311	FOUNDATION SECTIONS		●	
S320	FRAMING SECTIONS	●	●	
S321	FRAMING SECTIONS	●	●	
S322	FRAMING SECTIONS	●	●	
S323	FRAMING SECTIONS		●	
DEMOLITION DRAWINGS				
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D102	SECOND FLOOR DEMOLITION PLAN	●	●	
D201	FIRST FLOOR DEMOLITION RCP	●		
D202	SECOND FLOOR DEMOLITION RCP	●		
D401	DEMOLITION EXTERIOR ELEVATIONS	●	●	
D402	DEMOLITION ENLARGED EXTERIOR ELEVATIONS	●	●	
D501	DEMOLITION WALL SECTIONS			
D502	DEMOLITION WALL SECTIONS			
ARCHITECTURAL DRAWINGS				
L-001	SITE LANDSCAPE PLAN	●		
A001	ARCHITECTURAL SITE PLAN	●	●	
A011	FIRST FLOOR ROUGH-IN PLAN	●		
A012	SECOND FLOOR ROUGH-IN PLAN	●		
A101	FIRST FLOOR PLAN	●	●	
A102	SECOND FLOOR PLAN	●	●	
A111	ROOF PLAN	●	●	
A113	ROOF DETAILS	●		
A114	STANDING SEAM ROOF DETAILS	●		
A201	FIRST FLOOR REFLECTED CEILING PLAN	●	●	
A202	SECOND FLOOR REFLECTED CEILING PLAN	●	●	
A203	FIRST FLOOR CEILING SECTIONS & DETAILS	●	●	
A204	FIRST FLOOR CEILING SECTIONS & DETAILS	●	●	
A205	SECOND FLOOR CEILING SECTIONS & DETAILS	●	●	
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A211	ENLARGED CEILING PLAN DETAILS	●		
A212	ENLARGED CEILING PLAN DETAILS	●		
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A303	FIRST FLOOR ENLARGED PLANS, ELEVATIONS, & DETAILS	●		
A304	FIRST FLOOR ENLARGED PLANS, ELEVATIONS, & DETAILS	●		
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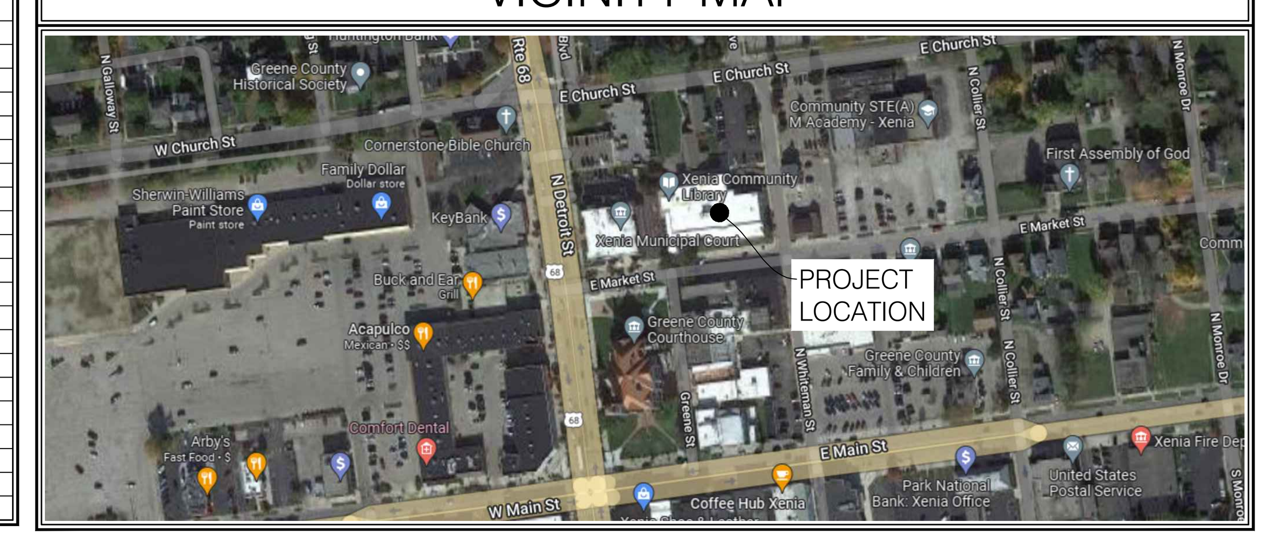
C

VICINITY MAP



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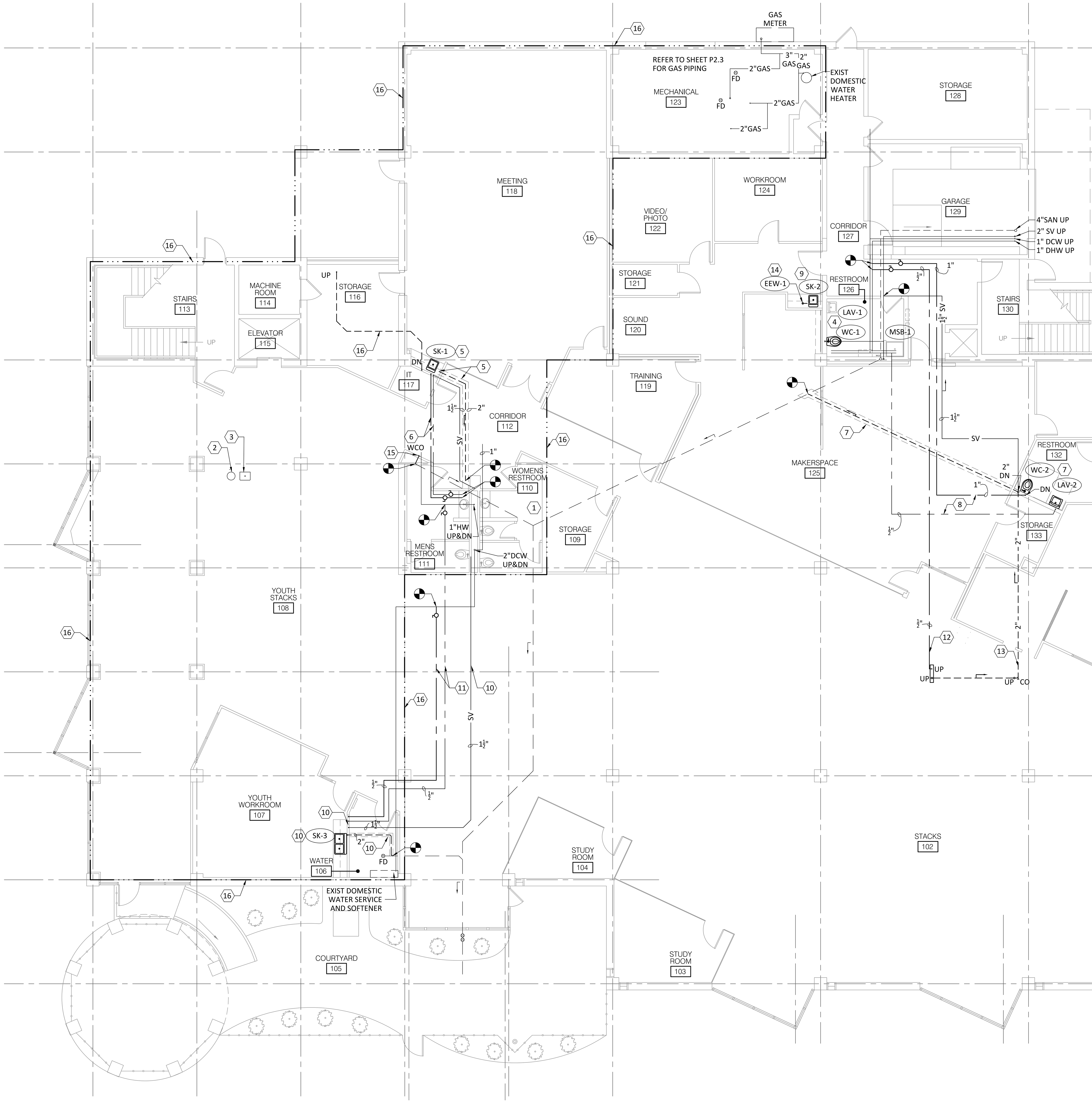
TITLE SHEET

Drawn By: BBJ, TW
Scale: AS NOTED
Job No.: 21-2113

T001



PLUMBING KEYED NOTES

1. EXISTING PLUMBING FIXTURES AND ASSOCIATED PIPING IN THESE RESTROOMS ARE TO REMAIN.
2. REMOVE EXISTING TANK STYLE ELECTRIC UNDER-COUNTER DOMESTIC HOT WATER HEATER INCLUDING ASSOCIATED PIPING BACK TO MAINS, PRESSURE RELIEF, CONTROLS, TEMPERATURE REGULATOR, DISCONNECT AND INSULATION.
3. REMOVE THE EXISTING SINK, INCLUDING ASSOCIATED DOMESTIC HOT AND COLD WATER VALVES, CONTROLS AND PIPING BACK TO MAINS, SANITARY AND VENTING. REMOVE WASTE TO BELOW FLOOR, SEAL, PATCH FLOOR LEVEL. REMOVE VENT PIPING BACK TO MAIN. REMOVE ALL INSULATION, SUPPORTS, HARDWARE AND FASTENERS.
4. EXISTING FIXTURES TO BE REPLACED WITH NEW, INCLUDING NEW DOMESTIC WATER STOPS AND THERMOSTATIC MIXING VALVES. PROVIDE CONNECTION TO EXISTING DOMESTIC HOT WATER, DOMESTIC COLD WATER, SANITARY AND VENTING. REFER TO DETAILS.
5. PROVIDE NEW SINK INCLUDING FAUCET, SUPPORTS AND HARDWARE, WATER STOPS AND SUPPLIES, TRAP AND CLEANOUT IN LOCATION SHOWN. PROVIDE NEW SANITARY WASTE LINE AND VENTING, INCLUDING SAW CUTTING OF FLOOR, EXCAVATION, FILL IN TRENCH AND PATCH FLOOR LEVEL. REFER TO DETAILS.
6. PROVIDE NEW DOMESTIC HOT AND COLD WATER TO SERVE NEW FIXTURE, INCLUDING MIXING VALVE, INSULATION AND ISOLATION VALVES AT CONNECTION TO EXISTING MAINS. REFER TO DETAILS.
7. C PROVIDE NEW WATER CLOSET AND LAVATORY, INCLUDING FLUSH VALVE AND FAUCET, CARRIERS, SUPPORTS AND HARDWARE, WATER STOPS AND SUPPLIES, THERMOSTATIC MIXING VALVE, TRAP AND CLEANOUT, IN THE LOCATIONS SHOWN. PROVIDE NEW SANITARY WASTE LINE AND VENTING, INCLUDING SAW CUTTING OF FLOOR, EXCAVATION, FILL IN TRENCH AND PATCH FLOOR LEVEL. REFER TO DETAILS.
8. PROVIDE NEW DOMESTIC HOT AND COLD WATER TO SERVE NEW FIXTURES, INCLUDING INSULATION AND ISOLATION VALVES, AT CONNECTION TO EXISTING. REFER TO DETAILS.
9. PROVIDE NEW SINK INCLUDING FAUCET, SUPPORTS AND HARDWARE, WATER STOPS AND SUPPLIES, TRAP AND CLEANOUT IN LOCATION SHOWN. PROVIDE NEW SANITARY WASTE LINE AND VENTING, BY CONNECTING TO EXISTING AT ADJOINING TOILET ROOM. PROVIDE NEW DOMESTIC HOT AND COLD WATER TO SERVE NEW FIXTURE, INCLUDING INSULATION, STOPS, MIXING VALVE, AND ISOLATION VALVES AT CONNECTION TO EXISTING AT ADJOINING TOILET ROOM. REFER TO DETAILS.
10. PROVIDE NEW SINK INCLUDING FAUCET, SUPPORTS AND HARDWARE, WATER STOPS AND SUPPLIES, TRAP AND CLEANOUT IN LOCATION SHOWN. PROVIDE NEW SANITARY WASTE LINE AND VENTING, INCLUDING SAW CUTTING OF FLOOR, EXCAVATION, FILL IN TRENCH AND PATCH FLOOR LEVEL. REFER TO DETAILS.
11. PROVIDE NEW DOMESTIC HOT AND COLD WATER TO SERVE NEW FIXTURE, INCLUDING MIXING VALVE, INSULATION AND ISOLATION VALVES AT CONNECTION TO EXISTING MAINS. REFER TO DETAILS.
12. PROVIDE NEW DOMESTIC COLD WATER BRANCH LINE, INCLUDING INSULATION AND ISOLATION VALVE AT CONNECTION TO THE EXISTING MAIN, TO SERVE WATER FEATURES ON FLOOR ABOVE. REFER TO DETAILS.
13. PROVIDE NEW TRAPPED SANITARY WASTE LINE FROM THE EXISTING WASTE MAIN OUTSIDE THE STAFF TOILET ROOM, UP TO SERVE WATER FEATURES ON FLOOR ABOVE. REFER TO DETAILS.
14. PROVIDE NEW DECK-MOUNTED EMERGENCY EYE WASH FIXTURE, INCLUDING THERMOSTATIC MIXING VALVE BELOW COUNTER-TOP, STOPS, INSULATED DOMESTIC HOT AND COLD WATER PIPING. REFER TO DETAILS.
15. PROVIDE NEW WALL CLEANOUT, EXTENDED FROM EXISTING WHERE SHOWN.
16. PROVIDE SANITARY WASTE LINE FROM SINK ABOVE, DOWN AND CONNECT TO WASTE LINE FOR SINK SK-1. REFER TO SHEET P1.2 AND DETAILS.
17. THE AREA OUTLINED WILL BE TEMPORARILY OCCUPIED BY THE OWNER DURING CONSTRUCTION. COORDINATE THE SCOPE AND SEQUENCE OF DEMOLITION CLOSELY WITH THE CONSTRUCTION MANAGER, OWNER, AND OTHER TRADES BEFORE BEGINNING ANY SYSTEM OUTAGE OR REMOVALS. REFER TO SPECIFICATIONS AND ARCHITECTURAL PLANS.

A P1.1 FIRST FLOOR PLUMBING - DEMO & NEW PLAN
Scale: 1/8" = 1'-0"

0 2' 4' 8' 16'

NOTE: REFER TO PLUMBING TITLE SHEET P0.0 FOR PLUMBING LEGEND AND GENERAL NOTES FOR THIS SHEET.

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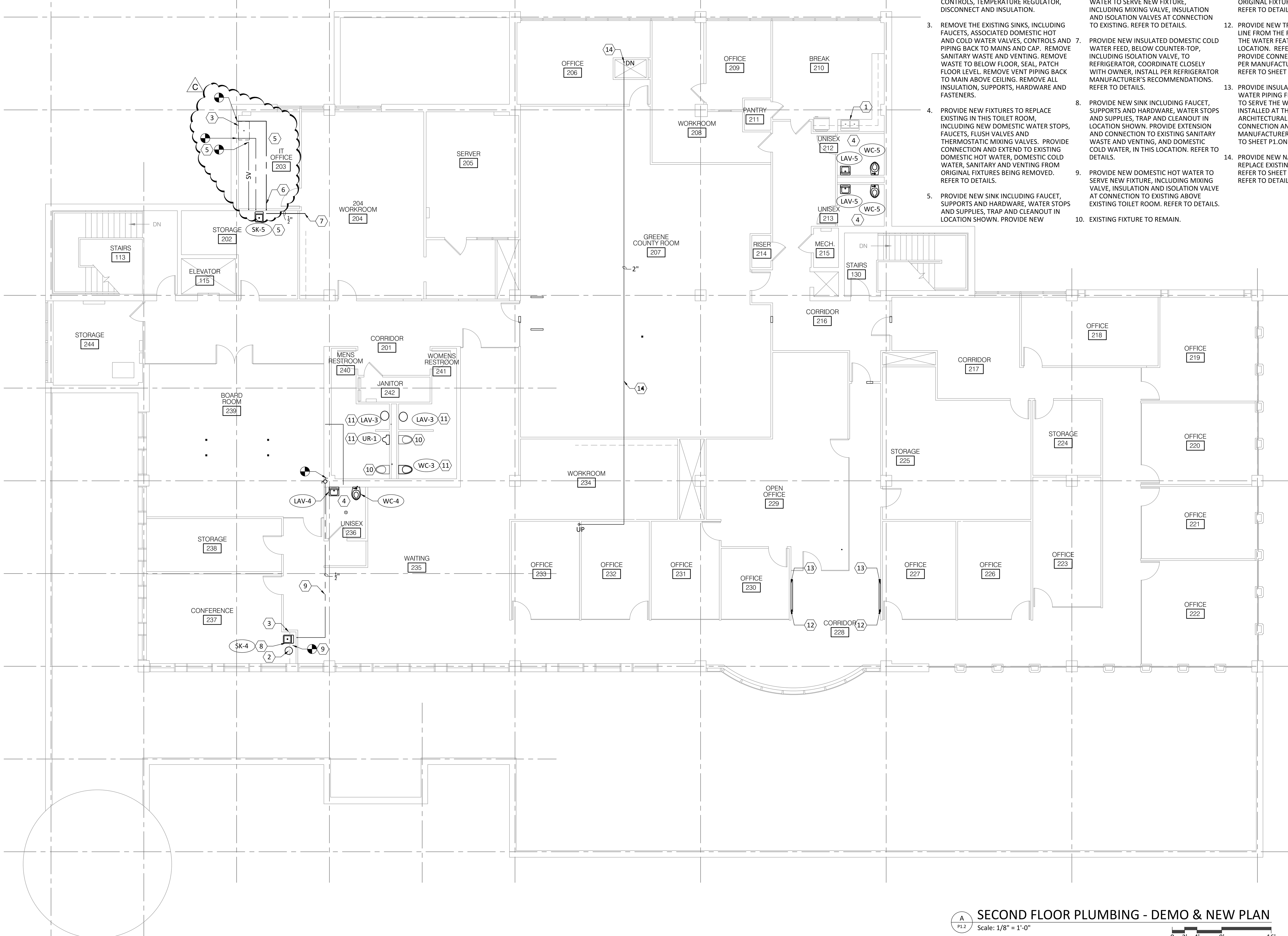
FIRST FLOOR PLUMBING DEMO & NEW PLAN

Drawn By:	TK, BBJ, MW
Scale:	AS NOTED
Job No.:	22-2038

P1.1



NOTES

1. EXISTING SINK, AND ASSOCIATED FAUCET, WATER STOPS, PIPING, DISPOSAL, TO REMAIN.
2. REMOVE EXISTING TANK STYLE ELECTRIC UNDER-COUNTER DOMESTIC HOT WATER HEATER INCLUDING ASSOCIATED PIPING BACK TO MAIN, PRESSURE RELIEF, CONTROLS, TEMPERATURE REGULATOR, DISCONNECT AND INSULATION.
3. REMOVE THE EXISTING SINKS, INCLUDING FAUCETS, ASSOCIATED DOMESTIC HOT AND COLD WATER VALVES, CONTROLS AND PIPING BACK TO MAINS AND CAP. REMOVE SANITARY WASTE AND VENTING. REMOVE WASTE TO BELOW FLOOR, SEAL, PATCH FLOOR LEVEL. REMOVE VENT PIPING BACK TO MAIN ABOVE CEILING. REMOVE ALL INSULATION, SUPPORTS, HARDWARE AND FASTENERS.
4. PROVIDE NEW FIXTURES TO REPLACE EXISTING IN THIS TOILET ROOM, INCLUDING NEW DOMESTIC WATER STOPS, FAUCETS, FLUSH VALVES AND THERMOSTATIC MIXING VALVES. PROVIDE CONNECTION AND EXTEND TO EXISTING DOMESTIC HOT WATER, DOMESTIC COLD WATER, SANITARY AND VENTING FROM ORIGINAL FIXTURES BEING REMOVED. REFER TO DETAILS.
5. PROVIDE NEW SINK INCLUDING FAUCET, SUPPORTS AND HARDWARE, WATER STOPS AND SUPPLIES, TRAP AND CLEANOUT IN LOCATION SHOWN. PROVIDE NEW SANITARY WASTE LINE AND VENTING, INCLUDING CORING FLOOR AND SLEEVE, FOR WASTE PIPING TO FLOOR BELOW, CONNECTED TO SANITARY PIPING ON FLOOR BELOW. REFER TO SHEET P1.1 AND DETAILS.
6. PROVIDE NEW DOMESTIC HOT AND COLD WATER TO SERVE NEW FIXTURE, INCLUDING MIXING VALVE, INSULATION AND ISOLATION VALVES AT CONNECTION TO EXISTING. REFER TO DETAILS.
7. PROVIDE NEW INSULATED DOMESTIC COLD WATER FEED, BELOW COUNTER-TOP, INCLUDING ISOLATION VALVE, TO REFRIGERATOR, COORDINATE CLOSELY WITH OWNER, INSTALL PER REFRIGERATOR MANUFACTURER'S RECOMMENDATIONS. REFER TO DETAILS.
8. PROVIDE NEW SINK INCLUDING FAUCET, SUPPORTS AND HARDWARE, WATER STOPS AND SUPPLIES, TRAP AND CLEANOUT IN LOCATION SHOWN. PROVIDE EXTENSION AND CONNECTION TO EXISTING SANITARY WASTE AND VENTING, AND DOMESTIC COLD WATER, IN THIS LOCATION. REFER TO DETAILS.
9. PROVIDE NEW DOMESTIC HOT WATER TO SERVE NEW FIXTURE, INCLUDING MIXING VALVE, INSULATION AND ISOLATION VALVE AT CONNECTION TO EXISTING ABOVE EXISTING TOILET ROOM. REFER TO DETAILS.
10. EXISTING FIXTURE TO REMAIN.
11. PROVIDE NEW FIXTURES TO REPLACE EXISTING IN THIS TOILET ROOM, INCLUDING NEW DOMESTIC WATER STOPS, FAUCET, FLUSH VALVE AND THERMOSTATIC MIXING VALVE. PROVIDE CONNECTION AND EXTEND TO EXISTING DOMESTIC HOT WATER, DOMESTIC COLD WATER, SANITARY AND VENTING FROM ORIGINAL FIXTURES BEING REMOVED. REFER TO DETAILS.
12. PROVIDE NEW TRAPPED SANITARY WASTE LINE FROM THE FLOOR BELOW TO SERVE THE WATER FEATURES INSTALLED AT THIS LOCATION. REFER TO ARCHITECTURAL. PROVIDE CONNECTION AND SPECIALTIES PER MANUFACTURER INSTRUCTIONS. REFER TO SHEET P1.1 AND DETAILS.
13. PROVIDE INSULATED DOMESTIC COLD WATER PIPING FROM THE FLOOR BELOW TO SERVE THE WATER FEATURES INSTALLED AT THIS LOCATION. REFER TO ARCHITECTURAL DRAWINGS. PROVIDE CONNECTION AND SPECIALTIES PER MANUFACTURER'S INSTRUCTIONS. REFER TO SHEET P1.ONE AND DETAILS.
14. PROVIDE NEW NATURAL GAS PIPING TO REPLACE EXISTING IN THIS LOCATION. REFER TO SHEET P1.3 FOR CONTINUATION. REFER TO DETAILS.

SECOND FLOOR PLUMBING - DEMO & NEW PLAN

A P1.2

Scale: 1/8" = 1'-0"

0 2' 4' 8' 16'

NOTE: REFER TO PLUMBING TITLE SHEET P0.0 FOR PLUMBING LEGEND AND GENERAL NOTES FOR THIS SHEET.

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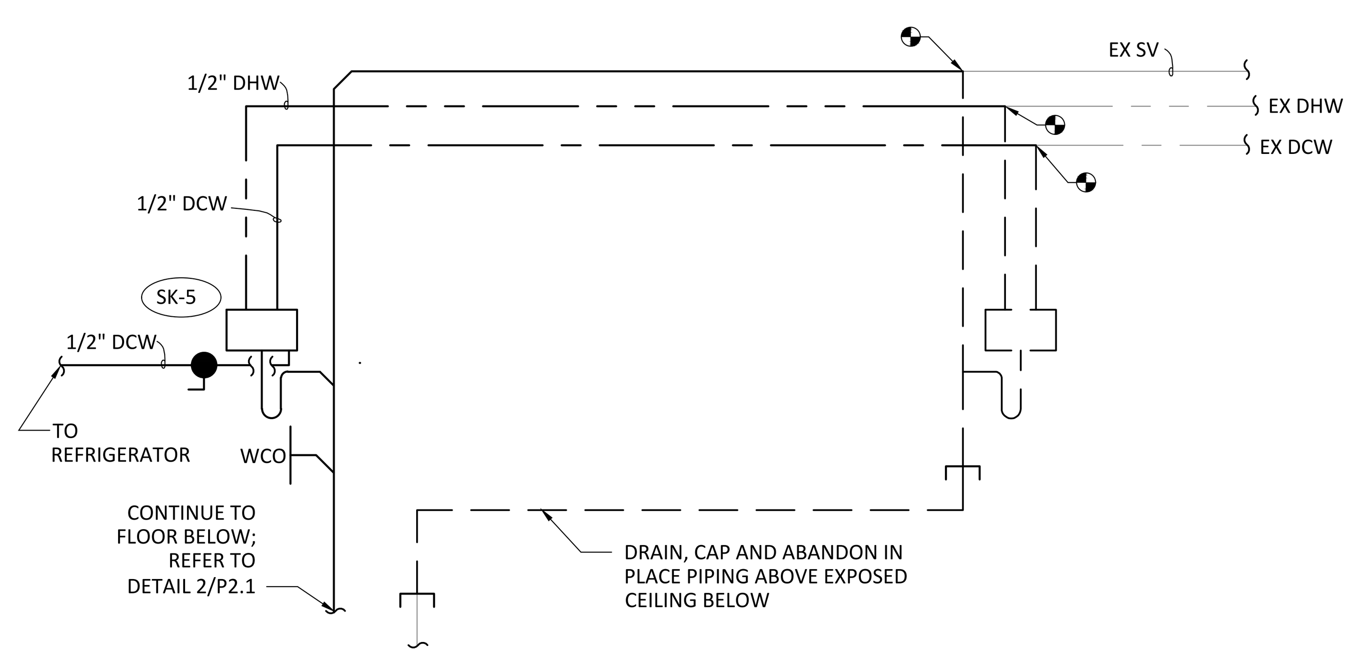
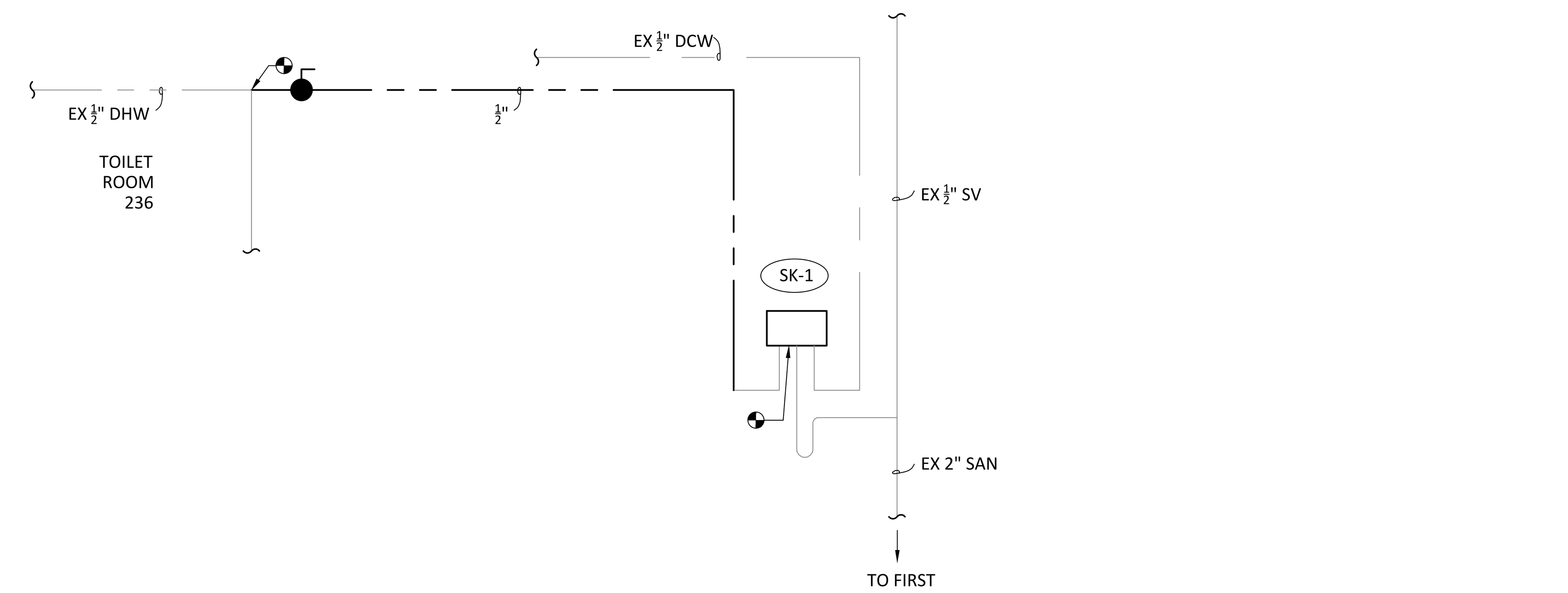
SECOND FLOOR PLUMBING DEMO & NEW PLAN

Drawn By:	TK, BBJ, MW
Scale:	AS NOTED
Job No.:	22-2038

P1.2



1 P2.2 DETAIL - PIPING SCHEMATIC - ROOM 202 - DOMESTIC WATER & DRAIN. WASTE, VENT
NOT TO SCALE



2 P2.2 DETAIL - PIPING SCHEMATIC - ROOM 237 - DOMESTIC WATER & DRAIN, WASTE, VENT
NOT TO SCALE

PLUMBING FIXTURES SCHEDULE

TAG	ROOM	DESCRIPTION	SAN	SV	DCW	DHW	FLOW	ADA	TRIM	DRAIN	REFERENCED MANUFACTURER	REFERENCED MODEL	NOTES
LAV-1	RESTROOM 126	WALL HUNG LAVATORY WITH CARRIER	2"	1-1/2"	1/2"	1/2"	.5 GPM	YES	4" CENTER-SET	GRID	ZURN	HIGH BACK Z5360	A
LAV-2	RESTROOM 132	WALL HUNG LAVATORY WITH CARRIER	2"	1-1/2"	1/2"	1/2"	.5 GPM	YES	4" CENTER-SET	GRID	ZURN	HIGH BACK Z5360	A
LAV-3	RESTROOMS 240, 241	DROP-IN COUNTERTOP LAVATORY	2"	1-1/2"	1/2"	1/2"	.5 GPM	YES	4" CENTER-SET	GRID	ZURN	COUNTERTOP Z5110	A
LAV-4	UNISEX TOILET ROOM 236	WALL HUNG LAVATORY WITH CARRIER	2"	1-1/2"	1/2"	1/2"	.5 GPM	YES	4" CENTER-SET	GRID	ZURN	HIGH BACK Z5360	A
LAV-5	UNISEX TOILET ROOMS 212, 213	WALL HUNG LAVATORY WITH CARRIER	2"	1-1/2"	1/2"	1/2"	.5 GPM	YES	4" CENTER-SET	GRID	ZURN	HIGH BACK Z5360	A
SK-1	MEETING ROOM 118	DROP-IN COUNTERTOP SINK	2"	1-1/2"	1/2"	1/2"	1.5 GPM	YES	4" CENTER-SET	GRID	ELKAY	LRAD 151765	B, G
SK-2	MAKERSPACE 125	DROP-IN COUNTERTOP SINK	2"	1-1/2"	1/2"	1/2"	1.5 GPM	YES	4" CENTER-SET	GRID	ELKAY	DLR221910PD	C, F
SK-3	YOUTH WORKROOM 107	DROP-IN COUNTERTOP, DOUBLE-BOWL SINK	2"	1-1/2"	1/2"	1/2"	1.5 GPM	YES	4" CENTER-SET	GRID	ELKAY	LRAD291865	D, H
SK-4	CONFERENCE 237	DROP-IN COUNTERTOP SINK	2"	1-1/2"	1/2"	1/2"	1.5 GPM	YES	4" CENTER-SET	GRID	ELKAY	LRAD 151765	B, G
SK-5	STORAGE 202	DROP-IN COUNTERTOP SINK	2"	1-1/2"	1/2"	1/2"	1.5 GPM	YES	4" CENTER-SET	GRID	ELKAY	PSLVR1917	E, F
EEW-1	MAKERSPACE 125	SWING-OPERATED EYE WASH	- -	- -	1/2"	1/2"	2.5 GPM	C	- -	- -	CHICAGO	8411-NF	I
UR-1	MENS RESTROOM 240	WALL MOUNTED URINAL	2"	1-1/2"	3/4"	- -	.125 GPF	YES	TOP-SPUD FLUSH VALVE	- -	ZURN	OMNI-FLO Z5755-U	J
						C							
WC-1	RESTROOM 126	WALL MOUNTED WATER CLOSET	3"	1-1/2"	1"	- -	1.28 GPF	YES	TOP-SPUD FLUSH VALVE	- -	ZURN	ECOVANTAGE Z5615-BWL	K, L
WC-2	RESTROOM 132	WALL MOUNTED WATER CLOSET	3"	1-1/2"	1"	- -	1.28 GPF	YES	TOP-SPUD FLUSH VALVE	- -	ZURN	ECOVANTAGE Z5615-BWL	K, L
WC-3	WOMENS RESTROOM 241	WALL MOUNTED WATER CLOSET	3"	1-1/2"	1"	- -	1.28 GPF	YES	TOP-SPUD FLUSH VALVE	- -	ZURN	ECOVANTAGE Z5615-BWL	K, L
WC-4	UNISEX TOILET ROOM 236	WALL MOUNTED WATER CLOSET	3"	1-1/2"	1"	- -	1.28 GPF	YES	TOP-SPUD FLUSH VALVE	- -	ZURN	ECOVANTAGE Z5615-BWL	K, L
WC-5	UNISEX TOILET ROOMS 212, 213	WALL MOUNTED WATER CLOSET	3"	1-1/2"	1"	- -	1.28 GPF	YES	TOP-SPUD FLUSH VALVE	- -	ZURN	ECOVANTAGE Z5615-BWL	K, L

NOTES

- A SLOAN SF-2350 BATTERY POWERED SENSOR OPERATED FAUCET
- B 15 X 17 X 6-1/2 DEEP
- C 22 X 19 X 10 DEEP
- D 29 X 18 X 6-1/2 DEEP
- E 19 X 17 X 6 DEEP
- F CHICAGO 526-E35-317ABCP SWIVEL FAUCET, WRIST BLADE HANDLES
- G CHICAGO 895-317RGD1E35ABCP, FIXED FAUCET, WRIST BLADE HANDLES
- H CHICAGO 895-317GN8AE35ABCP, SWIVEL FAUCET, WRIST BLADE HANDLES
- I DECK MOUNTED, YELLOW PLASTIC COATING, DUST CAPS
- J SLOAN 8186-BT BATTERY POWERED SENSOR OPERATED FLUSH VALVE WITH OVERRIDE
- K ELONGATED BOWL
- L SLOAN 8111-ECOS-.125 BATTERY POWERED SENSOR OPERATED FLUSH VALVE WITH OVERRIDE

NOTE: REFER TO PLUMBING TITLE SHEET P0.1 FOR KEYED NOTES AND GENERAL PROJECT NOTES FOR THIS SHEET.

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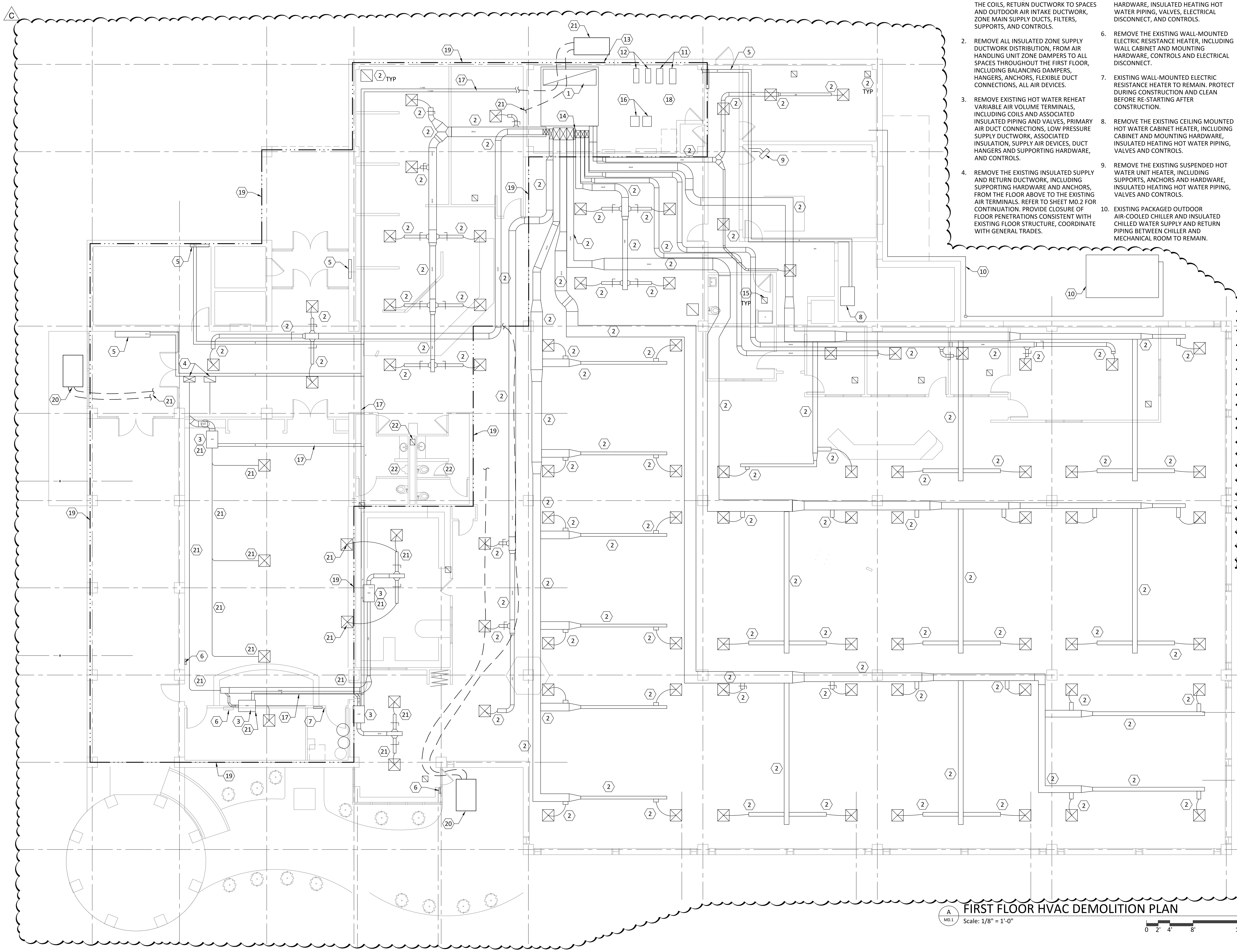
P2.2



FIRST FLOOR HVAC DEMOLITION PLAN

A / M0.1 — Scale: 1/8" = 1'-0"

0 2' 4' 8' 16'

NOTES

1. COMPLETELY DEMOLISH AND REMOVE THE EXISTING MULTI-ZONE AIR HANDLING UNIT, INCLUDING COILS, INSULATED PIPING TO THE COILS, RETURN DUCTWORK TO SPACES AND OUTDOOR AIR INTAKE DUCTWORK, ZONE MAIN SUPPLY DUCTS, FILTERS, SUPPORTS, AND CONTROLS.
2. REMOVE ALL INSULATED ZONE SUPPLY DUCTWORK DISTRIBUTION, FROM AIR HANDLING UNIT ZONE DAMPERS TO ALL SPACES THROUGHOUT THE FIRST FLOOR, INCLUDING BALANCING DAMPERS, HANGERS, ANCHORS, FLEXIBLE DUCT CONNECTIONS, ALL AIR DEVICES.
3. REMOVE EXISTING HOT WATER REHEAT VARIABLE AIR VOLUME TERMINALS, INCLUDING COILS AND ASSOCIATED INSULATED PIPING AND VALVES, PRIMARY AIR DUCT CONNECTIONS, LOW PRESSURE SUPPLY DUCTWORK, ASSOCIATED INSULATION, SUPPLY AIR DEVICES, DUCT HANGERS AND SUPPORTING HARDWARE, AND CONTROLS.
4. REMOVE THE EXISTING INSULATED SUPPLY AND RETURN DUCTWORK, INCLUDING SUPPORTING HARDWARE AND ANCHORS, FROM THE FLOOR ABOVE TO THE EXISTING AIR TERMINALS. REFER TO SHEET M0.2 FOR CONTINUATION. PROVIDE CLOSURE OF FLOOR PENETRATIONS CONSISTENT WITH EXISTING FLOOR STRUCTURE, COORDINATE WITH GENERAL TRADES.
5. REMOVE THE EXISTING WALL-MOUNTED HOT WATER CABINET HEATERS, INCLUDING WALL CABINETS AND MOUNTING HARDWARE, INSULATED HEATING HOT WATER PIPING, VALVES, ELECTRICAL DISCONNECT, AND CONTROLS.
6. REMOVE THE EXISTING WALL-MOUNTED ELECTRIC RESISTANCE HEATER, INCLUDING WALL CABINET AND MOUNTING HARDWARE, CONTROLS AND ELECTRICAL DISCONNECT.
7. EXISTING WALL-MOUNTED ELECTRIC RESISTANCE HEATER TO REMAIN. PROTECT DURING CONSTRUCTION AND CLEAN BEFORE RE-STARTING AFTER CONSTRUCTION.
8. REMOVE THE EXISTING CEILING MOUNTED HOT WATER CABINET HEATER, INCLUDING CABINET AND MOUNTING HARDWARE, INSULATED HEATING HOT WATER PIPING, VALVES AND CONTROLS.
9. REMOVE THE EXISTING SUSPENDED HOT WATER UNIT HEATER, INCLUDING SUPPORTS, ANCHORS AND HARDWARE, INSULATED HEATING HOT WATER PIPING, VALVES AND CONTROLS.
10. EXISTING PACKAGED OUTDOOR AIR-COOLED CHILLER AND INSULATED CHILLED WATER SUPPLY AND RETURN PIPING BETWEEN CHILLER AND MECHANICAL ROOM TO REMAIN.
11. EXISTING END-SUCTION CHILLED WATER PUMPS TO REMAIN.
12. REMOVE EXISTING END-SUCTION BUILDING HEATING HOT WATER PUMPS, INCLUDING EXISTING STARTERS. REFER TO DETAILS.
13. REMOVE EXISTING SHEET-METAL PLENUM AND PLYWOOD MASKING FROM BEHIND EXISTING LOUVER. CLEAN LOUVER AND SEAL FRAME AGAINST BUILDING WALL.
14. CAREFULLY REMOVE THE EXISTING I-WAVE ELECTRONIC AIR CLEANING DEVICES, INCLUDING ELECTRICAL CIRCUITS AND RACEWAYS (QUANTITY 4) AND STORE FOR REINSTALLATION.
15. REMOVE EXISTING CEILING RETURNS, REGISTERS AND GRILLES, TRANSFER GRILLES AND ASSOCIATED DUCTS, THROUGHOUT THE SPACES.
16. EXISTING GAS-FIRED CONDENSING HEATING HOT WATER BOILERS TO REMAIN. PROTECT DURING CONSTRUCTION.
17. COMPLETELY REMOVE ALL EXISTING INSULATED HEATING HOT WATER SUPPLY AND RETURN PIPING, INCLUDING HANGERS AND ANCHORS, FROM THE MECHANICAL ROOM OUT INTO THE SPACE TO ALL EXISTING CABINET HEATERS AND HOT WATER REHEAT AIR TERMINALS.
18. REFER TO SHEET M3 .1 OR DETAILED SCOPE OF WORK WITHIN THE EXISTING MECHANICAL ROOM.
19. THE AREA OUTLINED WILL BE TEMPORARILY OCCUPIED BY THE OWNER DURING CONSTRUCTION. COORDINATE THE SCOPE AND SEQUENCE OF DEMOLITION CLOSELY WITH THE CONSTRUCTION MANAGER, OWNER, AND OTHER TRADES BEFORE BEGINNING ANY SYSTEM OUTAGE OR REMOVALS. REFER TO SPECIFICATIONS AND ARCHITECTURAL PLANS.
20. CONTRACTOR TO SUBMIT FOR REVIEW A PLAN FOR TEMPORARY HVAC TO MAINTAIN CONDITIONS FOR CONTINUED TEMPORARY OCCUPANCY AND USAGE OF SPACE BY THE OWNER AND PUBLIC, BASED UPON THE USE OF PORTABLE PACKAGED UNITS PLACED TEMPORARILY IN THE APPROXIMATE LOCATION SHOWN. REFER TO THE SPECIFICATION FOR RETAINED TEMPORARY OCCUPANCY.
21. EXISTING MAIN DUCTS, TERMINAL UNITS, DISTRIBUTION AND AIR DEVICES ARE TO BE AVAILABLE FOR CONTINUED USE THROUGHOUT THE TEMPORARY OCCUPANCY PERIOD, CONNECTED TO TEMPORARY PORTABLE PACKAGED UNITS. TERMINAL UNITS TO BE HELD OPEN AND NO LONGER UNDER THE EXISTING CONTROL OF THE EXISTING BUILDING AUTOMATION SYSTEM. REFER TO THE SPECIFICATION FOR RETAINED TEMPORARY OCCUPANCY.
22. EXISTING TO REMAIN, NO WORK THESE ROOMS.

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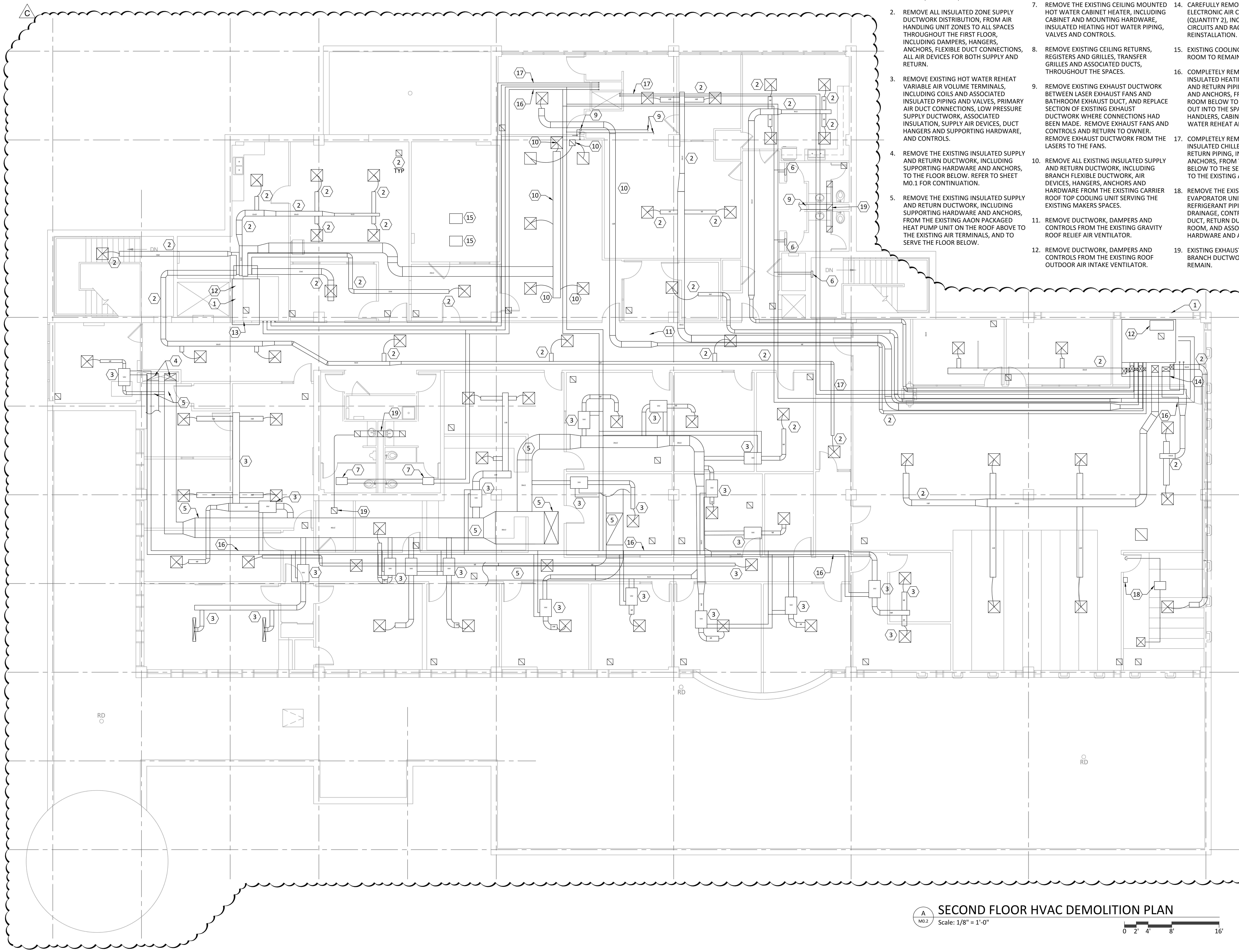
FIRST FLOOR HVAC DEMOLITION PLAN

Drawn By:	TK, BBJ, MW
Scale:	AS NOTED
Job No.:	22-2038

M0.1



SECOND FLOOR HVAC DEMOLITION PLAN

A M0.2

Scale: 1/8" = 1'-0"

0 2' 4' 8' 16'

NOTES

1. COMPLETELY DEMOLISH AND REMOVE THE EXISTING MULTI-ZONE AIR HANDLING UNIT, INCLUDING COILS, INSULATED PIPING TO THE COILS, RETURN AND OUTDOOR AIR DUCTWORK, ZONE MAIN SUPPLY DUCTS, FILTERS, SUPPORTS, AND CONTROLS.
2. REMOVE ALL INSULATED ZONE SUPPLY DUCTWORK DISTRIBUTION, FROM AIR HANDLING UNIT ZONES TO ALL SPACES THROUGHOUT THE FIRST FLOOR, INCLUDING DAMPERS, HANGERS, ANCHORS, FLEXIBLE DUCT CONNECTIONS, ALL AIR DEVICES FOR BOTH SUPPLY AND RETURN.
3. REMOVE EXISTING HOT WATER REHEAT VARIABLE AIR VOLUME TERMINALS, INCLUDING COILS AND ASSOCIATED INSULATED PIPING AND VALVES, PRIMARY AIR DUCT CONNECTIONS, LOW PRESSURE SUPPLY DUCTWORK, ASSOCIATED INSULATION, SUPPLY AIR DEVICES, DUCT HANGERS AND SUPPORTING HARDWARE, AND CONTROLS.
4. REMOVE THE EXISTING INSULATED SUPPLY AND RETURN DUCTWORK, INCLUDING SUPPORTING HARDWARE AND ANCHORS, TO THE FLOOR BELOW. REFER TO SHEET M0.1 FOR CONTINUATION.
5. REMOVE THE EXISTING INSULATED SUPPLY AND RETURN DUCTWORK, INCLUDING SUPPORTING HARDWARE AND ANCHORS, FROM THE EXISTING AAON PACKAGED HEAT PUMP UNIT ON THE ROOF ABOVE TO THE EXISTING AIR TERMINALS, AND TO SERVE THE FLOOR BELOW.
6. REMOVE THE EXISTING WALL-MOUNTED HOT WATER CABINET HEATERS, INCLUDING WALL CABINETS AND MOUNTING HARDWARE, INSULATED HEATING HOT WATER PIPING, VALVES AND CONTROLS.
7. REMOVE THE EXISTING CEILING MOUNTED HOT WATER CABINET HEATER, INCLUDING CABINET AND MOUNTING HARDWARE, INSULATED HEATING HOT WATER PIPING, VALVES AND CONTROLS.
8. REMOVE EXISTING CEILING RETURNS, REGISTERS AND GRILLES, TRANSFER GRILLES AND ASSOCIATED DUCTS, THROUGHOUT THE SPACES.
9. REMOVE EXISTING EXHAUST DUCTWORK BETWEEN LASER EXHAUST FANS AND BATHROOM EXHAUST DUCT, AND REPLACE SECTION OF EXISTING EXHAUST DUCTWORK WHERE CONNECTIONS HAD BEEN MADE. REMOVE EXHAUST FANS AND CONTROLS AND RETURN TO OWNER. REMOVE EXHAUST DUCTWORK FROM THE LASERS TO THE FANS.
10. REMOVE ALL EXISTING INSULATED SUPPLY AND RETURN DUCTWORK, INCLUDING BRANCH FLEXIBLE DUCTWORK, AIR DEVICES, HANGERS, ANCHORS AND HARDWARE FROM THE EXISTING CARRIER ROOF TOP COOLING UNIT SERVING THE EXISTING MAKERS SPACES.
11. REMOVE DUCTWORK, DAMPERS AND CONTROLS FROM THE EXISTING GRAVITY ROOF RELIEF AIR VENTILATOR.
12. REMOVE DUCTWORK, DAMPERS AND CONTROLS FROM THE EXISTING ROOF OUTDOOR AIR INTAKE VENTILATOR.
13. CAREFULLY REMOVE THE EXISTING I-WAVE ELECTRONIC AIR CLEANING DEVICE, INCLUDING ELECTRICAL CIRCUITS AND RACEWAYS AND STORE FOR REINSTALLATION.
14. CAREFULLY REMOVE THE EXISTING I-WAVE ELECTRONIC AIR CLEANING DEVICES (QUANTITY 2), INCLUDING ELECTRICAL CIRCUITS AND RACEWAYS AND STORE FOR REINSTALLATION.
15. EXISTING COOLING UNITS SERVING THE IT ROOM TO REMAIN.
16. COMPLETELY REMOVE ALL EXISTING INSULATED HEATING HOT WATER SUPPLY AND RETURN PIPING, INCLUDING HANGERS AND ANCHORS, FROM THE MECHANICAL ROOM BELOW TO THE SECOND FLOOR AND OUT INTO THE SPACE TO ALL EXISTING AIR HANDLERS, CABINET HEATERS AND HOT WATER REHEAT AIR TERMINALS.
17. COMPLETELY REMOVE ALL EXISTING INSULATED CHILLED WATER SUPPLY AND RETURN PIPING, INCLUDING HANGERS AND ANCHORS, FROM THE MECHANICAL ROOM BELOW TO THE SECOND FLOOR AND OUT TO THE EXISTING AIR HANDLERS.
18. REMOVE THE EXISTING SPLIT SYSTEM EVAPORATOR UNIT, INCLUDING REFRIGERANT PIPING, CONDENSATE DRAINAGE, CONTROLS, INSULATED SUPPLY DUCT, RETURN DUCT, AIR DEVICES IN THIS ROOM, AND ASSOCIATED SUPPORTS, HARDWARE AND ANCHORS.
19. EXISTING EXHAUST DUCT RISER, EXHAUST BRANCH DUCTWORK AND AIR DEVICES, TO REMAIN.

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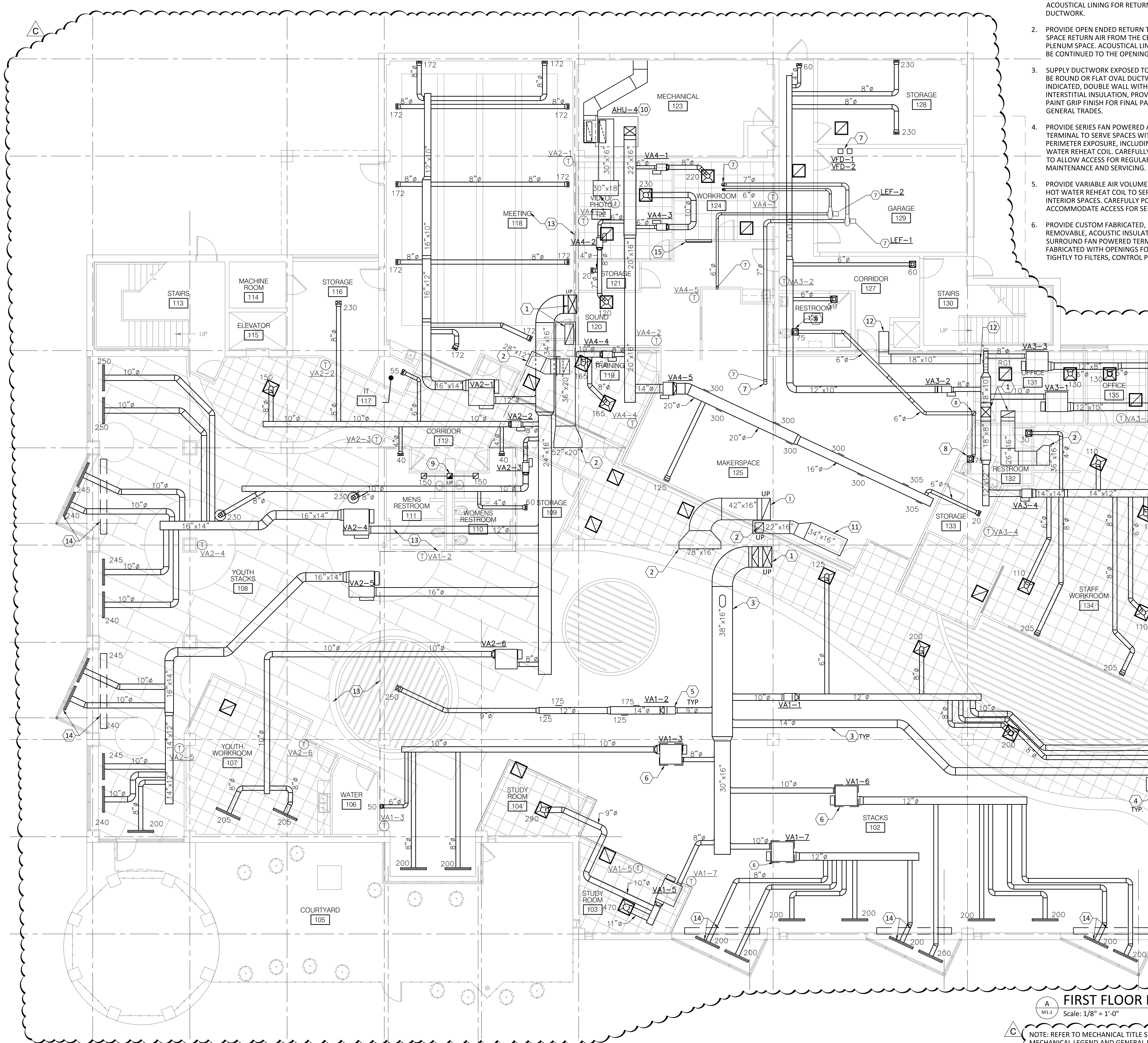
SECOND FLOOR
HVAC
DEMOLITION PLAN

Drawn By:	TK, BBJ, MW
Scale:	AS NOTED
Job No.:	22-2038

M0.2



FIRST FLOOR HVAC - NEW DUCTWORK PLAN

A / M1.1

Scale: 1/8" = 1'-0"

0 2' 4' 8' 16'

NOTE: REFER TO MECHANICAL TITLE SHEET M0.0 FOR MECHANICAL LEGEND AND GENERAL NOTES FOR THIS SHEET.

HVAC KEYED NOTES

1. PROVIDE INSULATED SUPPLY MAIN DUCTS AND RETURN MAIN DUCTS FROM THE UNITS ON THE ROOF. REFER TO SHEET M1 .2 FOR CONTINUATION. PROVIDE INTERNAL ACOUSTICAL LINING FOR RETURN DUCTWORK.
2. PROVIDE OPEN ENDED RETURN TO DRAW SPACE RETURN AIR FROM THE CEILING PLENUM SPACE. ACOUSTICAL LINING SHALL BE CONTINUED TO THE OPENING.
3. SUPPLY DUCTWORK EXPOSED TO VIEW TO BE ROUND OR FLAT OVAL DUCTWORK AS INDICATED, DOUBLE WALL WITH INTERSTITIAL INSULATION, PROVIDED WITH PAINT GRIP FINISH FOR FINAL PAINTING BY GENERAL TRADES.
4. PROVIDE SERIES FAN POWERED AIR TERMINAL TO SERVE SPACES WITH PERIMETER EXPOSURE, INCLUDING HOT WATER REHEAT COIL. CAREFULLY POSITION TO ALLOW ACCESS FOR REGULAR MAINTENANCE AND SERVICING.
5. PROVIDE VARIABLE AIR VOLUME BOX WITH HOT WATER REHEAT COIL TO SERVE INTERIOR SPACES. CAREFULLY POSITION TO ACCOMMODATE ACCESS FOR SERVICING.
6. PROVIDE CUSTOM FABRICATED, REMOVABLE, ACOUSTIC INSULATION TO SURROUND FAN POWERED TERMINAL. FABRICATED WITH OPENINGS FORMED TIGHTLY TO FILTERS, CONTROL PANEL, DUCT CONNECTIONS AND REHEAT COIL CONNECTIONS.
7. PROVIDE EXHAUST FAN SUSPENDED IN GARAGE TO DRAW FROM THE EXISTING LASER UNITS IN MAKERSPACE 125. REFER TO SHEET M1 .2 FOR CONTINUATION OF DISCHARGE DUCTWORK TO ROOF. BALANCE AIRFLOWS TO LASER MANUFACTURER RECOMMENDATIONS UTILIZING VARIABLE FREQUENCY DRIVES AND PITOT TRAVERSE PROBE.
8. PROVIDE NEW TOILET ROOM EXHAUST FOR EXISTING RESTROOM AND NEW RESTROOM, CONTINUED TO FLOOR ABOVE, AND EXHAUST FAN ON ROOF. CONTINUED ON SHEET M1 .2 AND SHEET M1.3.
9. EXISTING EXHAUST FOR RESTROOMS TO REMAIN, REFERS TO SHEET M1 .3 FOR FAN REPLACEMENT. BALANCE TO AIR FLOW RATES SHOWN.
10. PROVIDE NEW AIR HANDLING UNIT TO SERVE THE MAKERSPACE 125 AND ASSOCIATED ROOMS. REFER TO SHEET M3.1.
11. PROVIDE RELIEF GRILLE ON BOTTOM SIDE OF DUCT PLENUM, PROVIDE RELIEF DUCTWORK TO RELIEF FAN ON ROOF. CONTINUED ON SHEETS M1 .2 AND M1 .3.
12. PROVIDE TRANSFER AIR DUCT WITH END OPEN TO PLENUM ABOVE CEILINGS.
13. PHASING: PROVIDE WORK ACCORDING TO PHASING WITHIN THE AREA SHOWN WEST OF THIS LINE, WHICH REPRESENTS A TEMPORARY OCCUPANCY ZONE. REFER TO SHEETS PH001, PH002, PH003.
14. BID ALTERNATE: FOR DEDUCT BID ALTERNATE, POSITION LINEAR DIFFUSERS PARALLEL TO NEW CURTAINWALL SYSTEM IN EXISTING EXTERIOR WALL, ALIGNED WITH OTHER LINEAR DIFFUSERS SERVING THIS ZONE.
15. PROVIDE RETURN GRILLE IN WALL ABOVE ADJOINING CEILING TO TRANSFER RETURN AIR TO CEILING PLENUM SPACE (48"x24").

LEGEND

(#)Ø	ROUND DUCT
	FLAT OVAL DUCT
HD	HAND DAMPER
(T)	SPACE SENSOR

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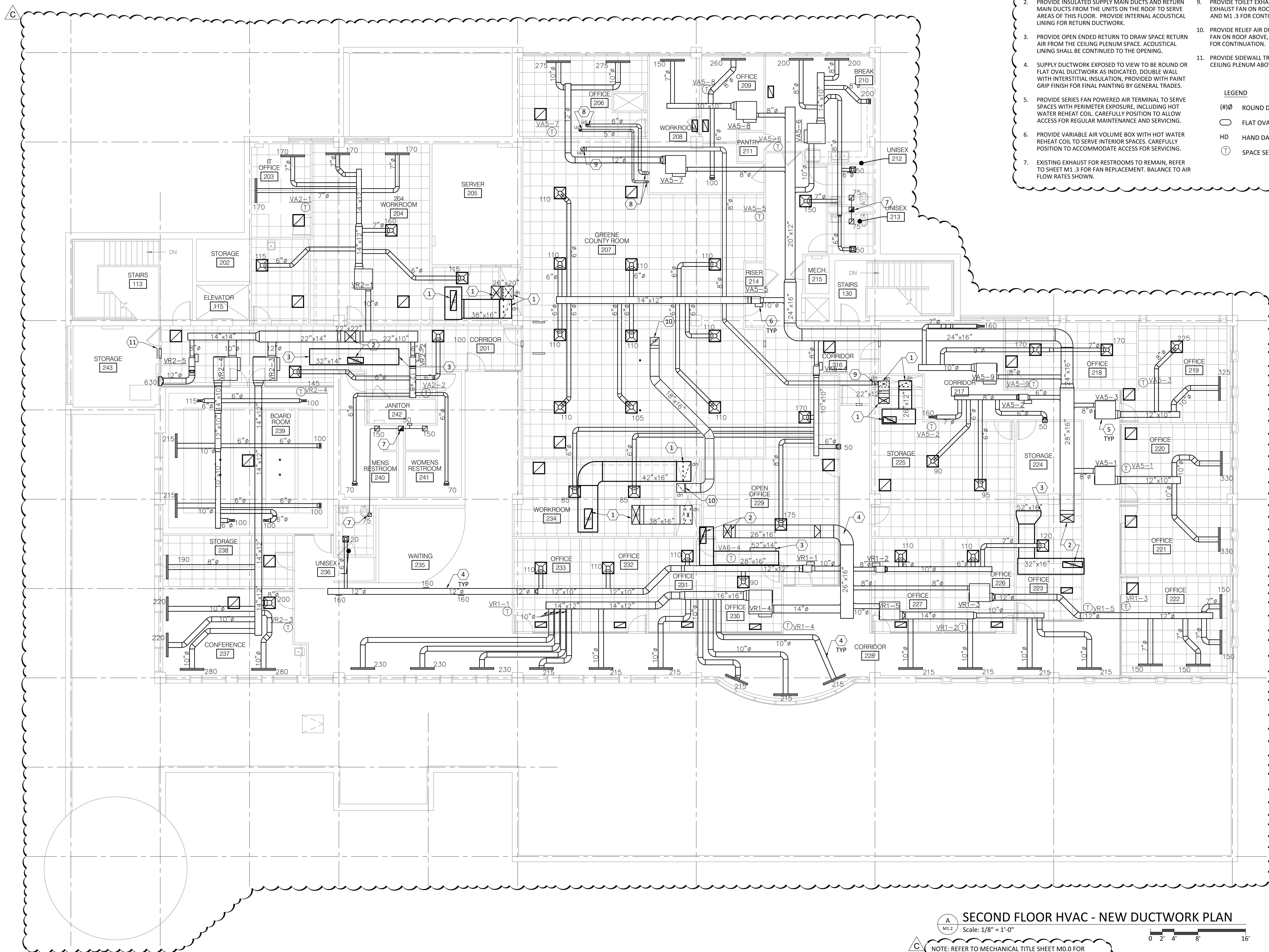
FIRST FLOOR
HVAC
NEW DUCTWORK

Drawn By:	TK, BBJ, MW
Scale:	AS NOTED
Job No.:	22-2038

M1.1



HVAC KEYED NOTES

1. PROVIDE INSULATED SUPPLY MAIN DUCTS AND RETURN MAIN DUCTS FROM THE UNITS ON THE ROOF TO FLOOR BELOW. REFER TO SHEET M1.1 FOR CONTINUATION.
2. PROVIDE INSULATED SUPPLY MAIN DUCTS AND RETURN MAIN DUCTS FROM THE UNITS ON THE ROOF TO SERVE AREAS OF THIS FLOOR. PROVIDE INTERNAL ACOUSTICAL LINING FOR RETURN DUCTWORK.
3. PROVIDE OPEN ENDED RETURN TO DRAW SPACE RETURN AIR FROM THE CEILING PLENUM SPACE. ACOUSTICAL LINING SHALL BE CONTINUED TO THE OPENING.
4. SUPPLY DUCTWORK EXPOSED TO VIEW TO BE ROUND OR FLAT OVAL DUCTWORK AS INDICATED, DOUBLE WALL WITH INTERSTITIAL INSULATION, PROVIDED WITH PAINT GRIP FINISH FOR FINAL PAINTING BY GENERAL TRADES.
5. PROVIDE SERIES FAN POWERED AIR TERMINAL TO SERVE SPACES WITH PERIMETER EXPOSURE, INCLUDING HOT WATER REHEAT COIL. CAREFULLY POSITION TO ALLOW ACCESS FOR REGULAR MAINTENANCE AND SERVICING.
6. PROVIDE VARIABLE AIR VOLUME BOX WITH HOT WATER REHEAT COIL TO SERVE INTERIOR SPACES. CAREFULLY POSITION TO ACCOMMODATE ACCESS FOR SERVICING.
7. EXISTING EXHAUST FOR RESTROOMS TO REMAIN, REFER TO SHEET M1 .3 FOR FAN REPLACEMENT. BALANCE TO AIR FLOW RATES SHOWN.
8. PROVIDE LASER EXHAUST DISCHARGE DUCTWORK FROM FLOOR BELOW TO DISCHARGE ON ROOF ABOVE, REFER TO SHEETS M1 .1 AND M1 .3 FOR CONTINUATION.
9. PROVIDE TOILET EXHAUST FROM FLOOR BELOW TO EXHAUST FAN ON ROOF ABOVE, REFER TO SHEETS M1.1 AND M1 .3 FOR CONTINUATION.
10. PROVIDE RELIEF AIR DUCT FROM FLOOR BELOW TO RELIEF FAN ON ROOF ABOVE, REFER TO SHEETS M1 .1 AND M1 .3 FOR CONTINUATION.
11. PROVIDE SIDEWALL TRANSFER AIR OPENING TO THE CEILING PLENUM ABOVE THE CORRIDOR.

LEGEND

(#)Ø	ROUND DUCT
	FLAT OVAL DUCT
HD	HAND DAMPER
T	SPACE SENSOR

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SECOND FLOOR HVAC - NEW DUCTWORK PLAN

A M1.2 Scale: 1/8" = 1'-0"

0 2' 4' 8' 16'

NOTE: REFER TO MECHANICAL TITLE SHEET M0.0 FOR MECHANICAL LEGEND AND GENERAL NOTES FOR THIS SHEET.

SECOND FLOOR HVAC NEW DUCTWORK

Drawn By:	TK, BBJ, MW
Scale:	AS NOTED
Job No.:	22-2038

M1.2

HVAC PIPING PLAN KEYED NOTES

1. PROVIDE INSULATED BRANCH HEATING HOT WATER SUPPLY AND RETURN PIPING TO CABINET HEATERS, UNIT HEATERS, AIR TERMINALS, 3/4 INCH PIPING DIAMETER UNLESS OTHERWISE NOTED ON PLANS.
2. PROVIDE INDIVIDUAL ISOLATION VALVES, CONTROL VALVES, BALANCING DEVICES, SERVICE VENTS AND DRAINS, STRAINERS, FOR CONNECTION TO UNIT HEATERS AND CABINET HEATERS, FOLLOWING MANUFACTURER'S INSTALLATION RECOMMENDATIONS. REFER TO DETAILS.
3. PROVIDE INDIVIDUAL ISOLATION VALVES, CONTROL VALVES, BALANCING DEVICES, SERVICE VENTS AND DRAINS, STRAINERS, FOR CONNECTION TO AIR TERMINAL UNIT REHEAT COILS, FOLLOWING MANUFACTURER'S INSTALLATION RECOMMENDATIONS. REFER TO DETAILS.
4. PROVIDE CABINET HEATER SURFACE MOUNTED ON EXISTING WALL, MINIMUM 7 FEET SIX INCH ABOVE FINISHED FLOOR. PROVIDE INSULATED PIPING TIGHT TO EXISTING WALL. COORDINATE WITH EXISTING CONDITIONS, EXISTING ELECTRICAL AND FIRE PROTECTION. SECURE TO WALL FOR MANUFACTURER'S RECOMMENDATIONS.
5. PROVIDE CABINET HEATER RECESSED IN WALL UTILIZING EXISTING WALL RECESS FROM ORIGINAL UNIT. PROVIDE FACTORY WALL FLANGE KIT AROUND UNIT FACE AND OVER OPENING TO CONCEAL OPENING EDGES AND PROVIDE FINISHED LOOK.
6. PROVIDE DUCTLESS HEAT PUMP SYSTEM FOR HEATING AND COOLING TO THE ELEVATOR MACHINE ROOM. MOUNT HEAT PUMP TO EXISTING EXTERIOR WALL MINIMUM 7 FEET SIX INCH ABOVE GRADE UTILIZING MANUFACTURER'S WALL BRACKETS. FASTEN SECURELY TO BRACKET. PROVIDE REFRIGERANT PIPING BEHIND HEAT PUMP INTO THE INDOOR WALL HUNG EVAPORATOR CONSOLE. INSTALL PER MANUFACTURER'S RECOMMENDATIONS.
7. PROVIDE INSULATED PUMPED CONDENSATE DRAIN LINE BETWEEN CONDENSATE PUMP IN THE EVAPORATOR CONSOLE AND EXISTING SERVICE SINK.
8. PHASING: PROVIDE WORK ACCORDING TO PHASING WITHIN THE AREA SHOWN WEST OF THIS LINE, WHICH REPRESENTS A TEMPORARY OCCUPANCY ZONE. REFER TO SHEETS PH001, PH002, PH003.

LEGEND

HHWS	HEATING HOT WATER SUPPLY
HHWR	HEATING HOT WATER RETURN

FIRST FLOOR HVAC - NEW PIPING PLAN

A M2.1 Scale: 1/8" = 1'-0"

0 2' 4' 8' 16'

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FIRST FLOOR HVAC NEW PIPING PLAN

Drawn By:	TK, BBJ, MW
Scale:	AS NOTED
Job No.:	22-2038

M2.1

SECOND FLOOR HVAC - NEW PIPING PLAN

A / M2.2

Scale: 1/8" = 1'-0"

0 2' 4' 8' 16'

HVAC PIPING PLAN KEYED NOTES

1. PROVIDE INSULATED BRANCH HEATING HOT WATER SUPPLY AND RETURN PIPING TO AIR TERMINALS, 3/4 INCH PIPING DIAMETER UNLESS OTHERWISE NOTED ON PLANS.
2. PROVIDE INDIVIDUAL ISOLATION VALVES, CONTROL VALVES, BALANCING DEVICES, SERVICE VENTS AND DRAINS, STRAINERS, FOR CONNECTION TO AIR TERMINAL UNIT REHEAT COILS, FOLLOWING MANUFACTURER'S INSTALLATION RECOMMENDATIONS. REFER TO DETAILS.
3. PROVIDE ELECTRIC RADIANT CEILING PANEL HEATER, INCLUDING FACTORY LINE VOLTAGE THERMOSTAT WITH HIDDEN ADJUSTMENT. INSTALL PER MANUFACTURER'S RECOMMENDATIONS.
4. PROVIDE BYPASS WITH PRESSURE INDEPENDENT BALANCING VALVE AND UNIONS TO MAINTAIN MINIMUM FLOW OF 8 GPM.
5. PROVIDE BYPASS WITH PRESSURE INDEPENDENT MODULATING CONTROL VALVE AND UNIONS TO MAINTAIN MINIMUM FLOW FOR CHILLER, SET TO 80 GPM.

LEGEND

CHWS	CHILLED WATER SUPPLY
CHWR	CHILLED WATER RETURN
	ISOLATION VALVE

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SECOND FLOOR HVAC NEW PIPING PLAN

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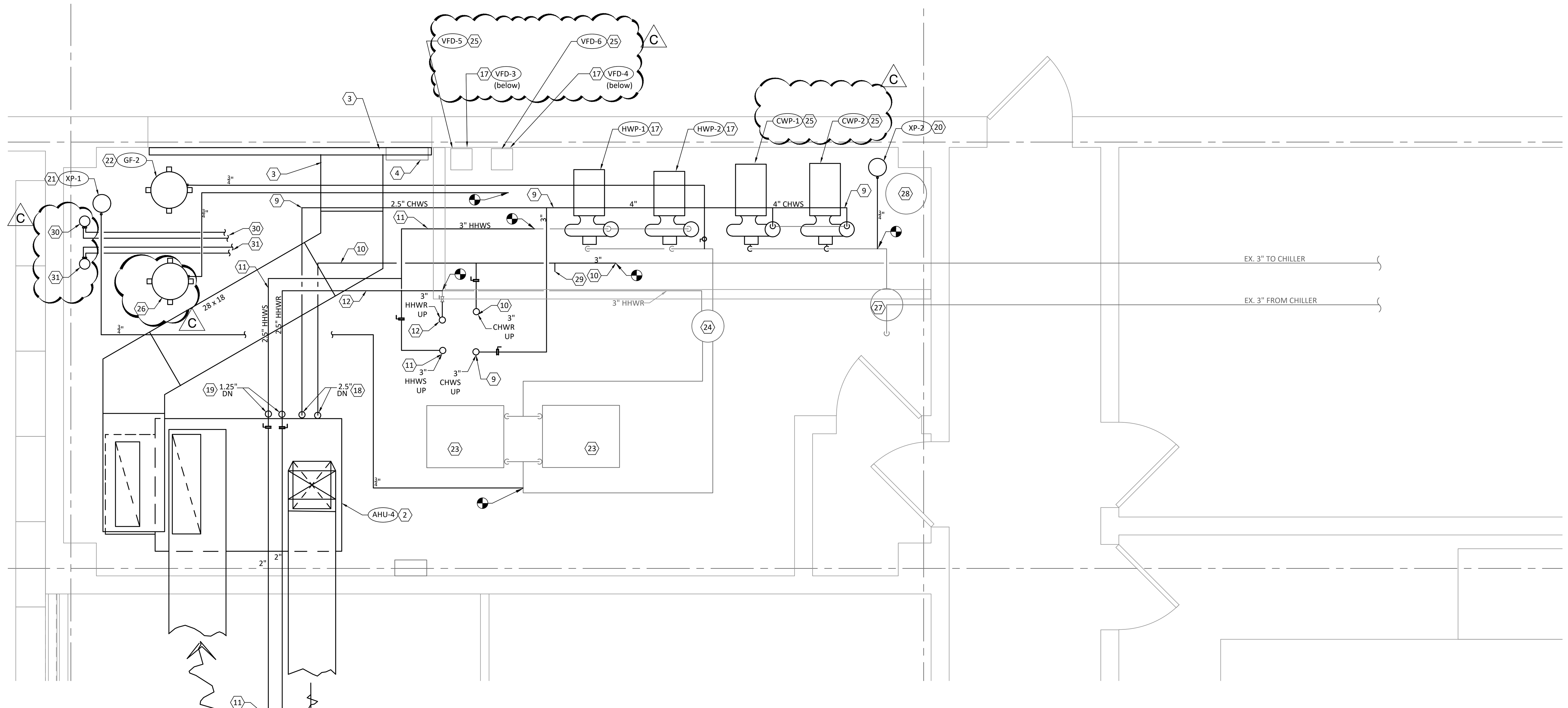
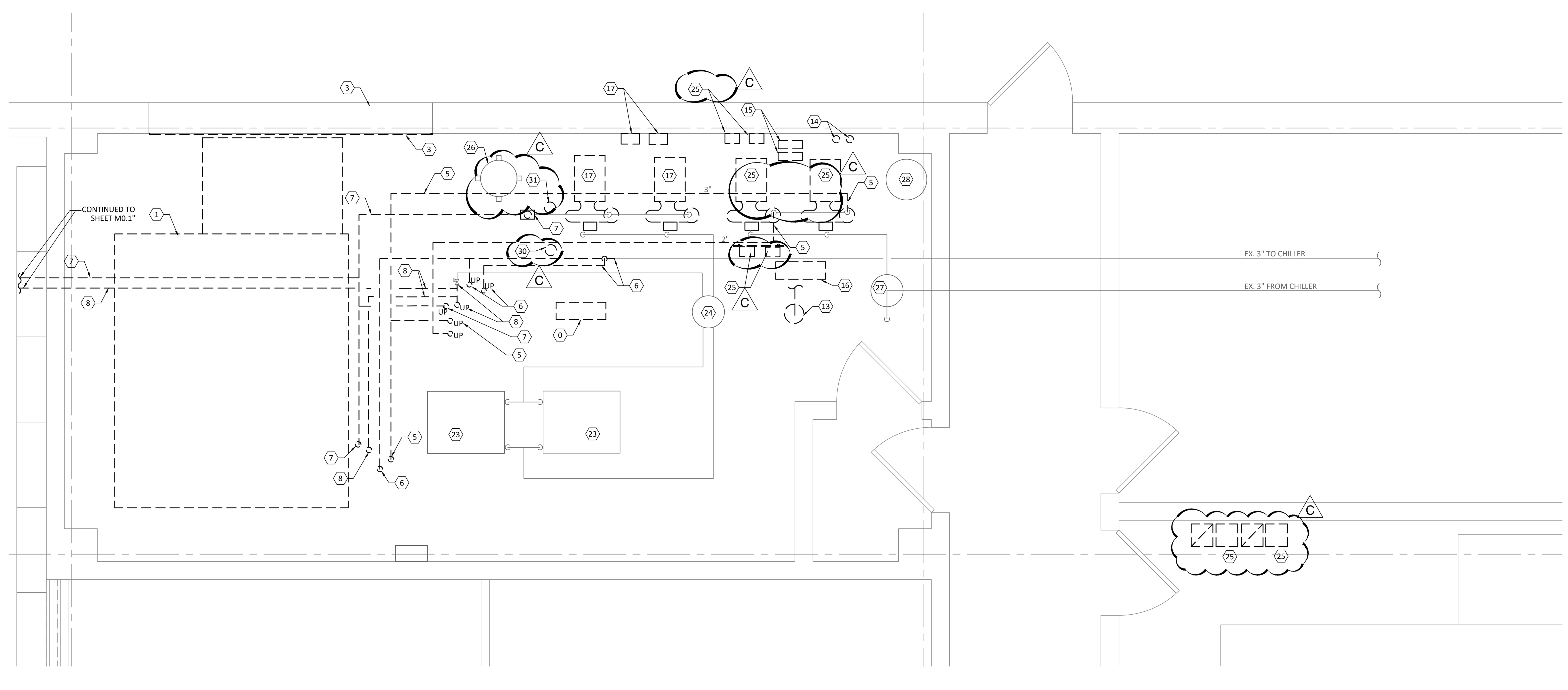
Scale:	AS NOTED
Job No.:	22-2038

M2.2



1 M3.1 ENLARGED PLAN - MAIN MECHANICAL ROOM 123 - HVAC WORK

Scale: 3/8" = 1'-0"



2 M3.1 ENLARGED PLAN - MAIN MECHANICAL ROOM 123 - DEMOLITION

Scale: 3/8" = 1'-0"

NOTES

1. COMPLETELY DEMOLISH AND REMOVE THE EXISTING MULTI-ZONE AIR HANDLING UNIT, INCLUDING COILS, INSULATED PIPING TO THE COILS, RETURN DUCTWORK TO SPACES AND OUTDOOR AIR INTAKE DUCTWORK, ZONE MAIN SUPPLY DUCTS, FILTERS, SUPPORTS, AND CONTROLS.
2. PROVIDE NEW AIR HANDLING UNIT INCLUDING VIBRATION ISOLATORS, SUPPLY DUCTWORK, MIXING PLENUM, RETURN DUCTWORK, AND CONTROLS. PROVIDE NEW CHILLED WATER AND HEATING HOT WATER SPECIALTIES. REFER TO DETAILS.
3. REMOVE BOARDS AND CLEAN EXISTING LOUVER. PROVIDE NEW INSULATED LOUVER PLENUM BEHIND ENTIRE LOUVER. PROVIDE NEW OUTDOOR AIR VENTILATION DUCTWORK TO THE AIR HANDLING UNIT MIXING PLENUMS, COMPLETE WITH AIRFLOW STATION.
4. MAINTAIN THE EXISTING COMBUSTION AIR INTAKE BY CONNECTING TO NEW PLENUM.
5. REMOVE EXISTING CHILLED WATER SUPPLY PIPING FROM EXISTING CHILLED WATER PUMPS WHERE INDICATED, INCLUDING PIPING TO ORIGINAL AIR HANDLING UNIT AND BRANCHES UP TO THE SECOND FLOOR. MAINTAIN EXISTING ISOLATION VALVES, MANIFOLD, FLEXIBLE CONNECTORS AND TRIPLE-DUTY VALVES AT EXISTING PUMPS.
6. REMOVE EXISTING CHILLED WATER RETURN PIPING FROM EXISTING CHILLED WATER SYSTEM WHERE INDICATED, INCLUDING PIPING TO ORIGINAL AIR HANDLING UNIT AND BRANCHES UP TO THE SECOND FLOOR.
7. REMOVE EXISTING HEATING HOT WATER SUPPLY PIPING FROM THE EXISTING HEATING HOT WATER SYSTEM WHERE INDICATED, INCLUDING REMOVAL OF THE ORIGINAL BALANCING VALVE, PIPING TO ORIGINAL AIR HANDLING UNIT AND BRANCHES UP TO THE SECOND FLOOR.
8. REMOVE EXISTING HEATING HOT WATER RETURN PIPING FROM THE EXISTING HEATING HOT WATER SYSTEM WHERE INDICATED, INCLUDING PIPING TO ORIGINAL AIR HANDLING UNIT AND BRANCHES UP TO THE SECOND FLOOR. MAINTAIN THE EXISTING BRANCH ISOLATION VALVE.
9. PROVIDE NEW INSULATED CHILLED WATER SUPPLY PIPING FROM THE PUMPS TO SERVICE THE BUILDING'S NEW AIR HANDLING UNITS, INCLUDING NEW RISER TO SECOND FLOOR. REFER TO SHEET M2.2 FOR CONTINUATION. C
10. PROVIDE NEW INSULATED CHILLED WATER RETURN PIPING FROM POINTS INDICATED TO SERVICE THE BUILDING'S NEW AIR HANDLING UNITS, INCLUDING NEW RISER TO THE SECOND FLOOR. UTILIZE THE EXISTING BRANCH ISOLATION VALVE FOR ISOLATION OF THE RISER. REFER TO SHEET M2.2 FOR CONTINUATION.
11. PROVIDE NEW INSULATED HEATING HOT WATER SUPPLY PIPING FROM POINTS INDICATED TO SERVICE THE BUILDING'S NEW AIR HANDLING UNITS, AIR TERMINALS AND CABINET HEATERS, INCLUDING NEW RISER TO THE SECOND FLOOR. REFER TO SHEETS M2.1 AND M2.2 FOR CONTINUATION.
12. PROVIDE NEW INSULATED HEATING HOT WATER RETURN PIPING FROM POINTS INDICATED TO SERVICE THE BUILDING'S NEW AIR HANDLING UNITS, AIR TERMINALS AND CABINET HEATERS, INCLUDING NEW RISER TO THE SECOND FLOOR. REFER TO SHEETS M2.1 AND M2.2 FOR CONTINUATION.
13. REMOVE THE EXISTING ABANDONED SEPARATOR AND THE ASSOCIATED ABANDONED PIPING, INCLUDING ALL INSULATION AND SUPPORTS.
14. REMOVE THE EXISTING ABANDONED EXPANSION TANK AND ASSOCIATED ABANDONED PIPING, INCLUDING ALL INSULATION AND SUPPORTING HARDWARE.
15. REMOVE THE EXISTING CHILLED WATER LOOP EXPANSION TANK AND ASSOCIATED PIPING.
16. REMOVE THE EXISTING HEATING HOT WATER LOOP EXPANSION TANK AND ASSOCIATED PIPING.
17. REMOVE THE EXISTING HEATING HOT WATER PUMPS AND STARTERS. MAINTAIN EXPANSION DEVICES ISOLATION VALVES, TRIPLE-DUTY VALVES. PROVIDE NEW HEATING HOT WATER BUILDING LOOP PUMPS TO REPLACE THE EXISTING. PROVIDE NEW VARIABLE FREQUENCY DRIVES FOR EACH NEW PUMP. REFER TO DETAILS.
18. PROVIDE NEW INSULATED CHILLED WATER BRANCH PIPING TO THE NEW AIR HANDLING UNIT COOLING COIL, INCLUDING VALVES AND SUPPORTING HARDWARE. REFER TO DETAILS.
19. PROVIDE NEW INSULATED HEATING HOT WATER BRANCH PIPING TO THE NEW AIR HANDLING UNIT HEATING COIL, INCLUDING VALVES AND SUPPORTING HARDWARE. REFER TO DETAILS.
20. PROVIDE NEW DIAPHRAGM TYPE EXPANSION TANK FOR THE CHILLED WATER LOOP, INCLUDING PIPING TO CONNECT TO EXISTING SYSTEM. INSTALL PER MANUFACTURER'S INSTRUCTIONS. PROVIDE ALL INSULATION AND SUPPORTING HARDWARE.
21. PROVIDE NEW DIAPHRAGM TYPE EXPANSION TANK FOR THE HEATING WATER BUILDING LOOP, INCLUDING PIPING TO CONNECT TO EXISTING SYSTEM. INSTALL PER MANUFACTURER'S INSTRUCTIONS. PROVIDE ALL INSULATION AND SUPPORTING HARDWARE.
22. PROVIDE NEW AUTOMATIC GLYCOL FEED UNIT, INCLUDING FACTORY SUPPORTS, ANCHORED TO CONCRETE FLOOR. PROVIDE BRANCH PIPING TO EXISTING HEATING HOT WATER BUILDING LOOP. REFER TO DETAILS.
23. EXISTING BUILDING HEATING BOILERS TO REMAIN.
24. EXISTING HEATING HOT WATER BUILDING LOOP AIR SEPARATOR TO REMAIN.
25. REMOVE THE EXISTING CHILLED WATER PUMPS AND DISCONNECTS AND VFD'S. MAINTAIN EXISTING ISOLATION VALVES, FLEXIBLE CONNECTORS AND TRIPLE-DUTY VALVES. PROVIDE NEW CHILLED WATER BUILDING LOOP PUMPS TO REPLACE THE EXISTING. INCLUDING NEW SUCTION DIFFUSERS. PROVIDE NEW VARIABLE FREQUENCY DRIVE FOR EACH PUMP. C
26. RELOCATE EXISTING AUTOMATIC GLYCOL FEED UNIT FOR CHILLED WATER LOOP. PROVIDE EXTENSION OF SYSTEM PIPING, CONTROLS AND POWER. ANCHOR TO FLOOR.
27. EXISTING CHILLED WATER LOOP AIR SEPARATOR TO REMAIN.
28. EXISTING DOMESTIC HOT WATER HEATER TO REMAIN.
29. PROVIDE CHILLED WATER FLOW METER. C
30. RELOCATE EXISTING CHEMICAL FEEDER, SUPPORTS AND VALVES TO LOCATION SHOWN, PROVIDE INSULATED 3/4" PIPING TO EXTEND AND CONNECT BACK TO SYSTEM.
31. RELOCATE EXISTING CHEMICAL FEEDER, SUPPORTS AND VALVES TO LOCATION SHOWN, PROVIDE 1" PIPING TO EXTEND AND CONNECT BACK TO SYSTEM.

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COMPLETE RENOVATION/MECHANICAL UPGRADES:

Greene County Public Library

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76 EAST MARKET STREET
XENIA, OH 45385

REVISIONS / SUBMISSIONS

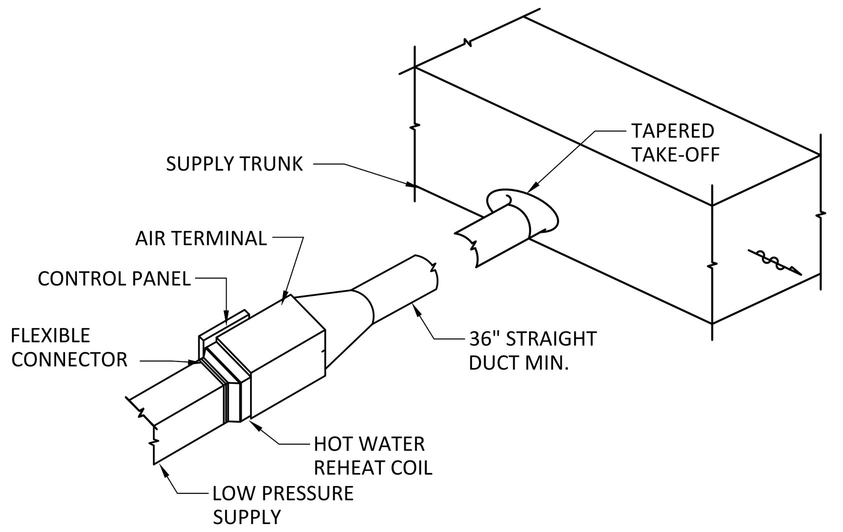
NO.	DESCRIPTION	DATE
	BID ISSUE	01/04/23
C	ADDENDUM C	01/27/23

PRELIMINARY BID NOT FOR CONSTRUCTION

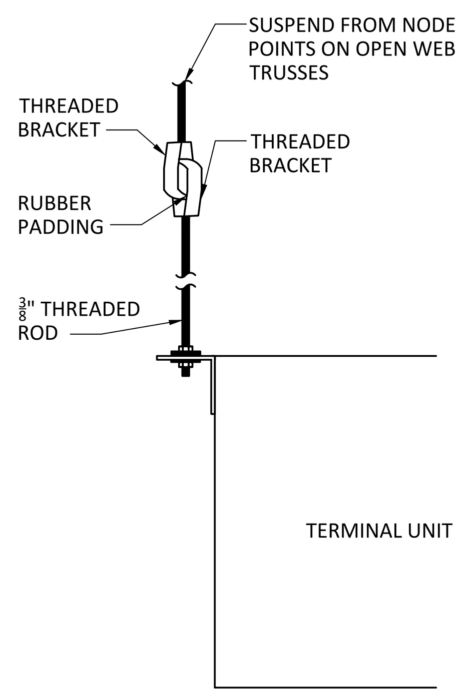
HVAC DETAILS AND DIAGRAMS

Drawn By:	TK, BBJ, MW
Scale:	AS NOTED
Job No.:	22-2038

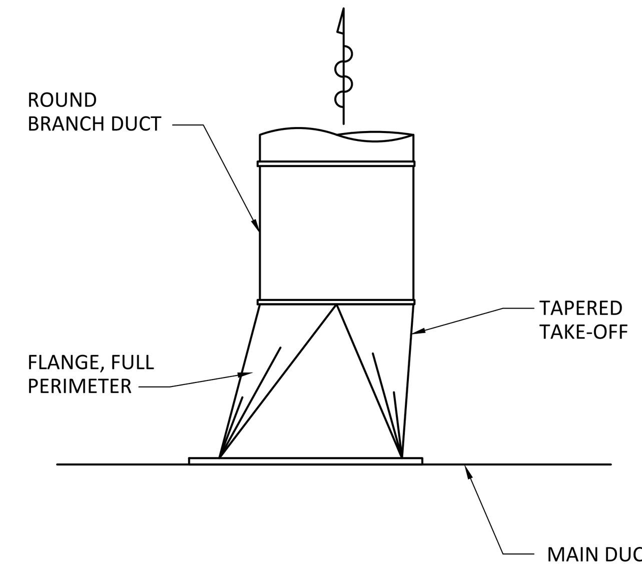
M3.1



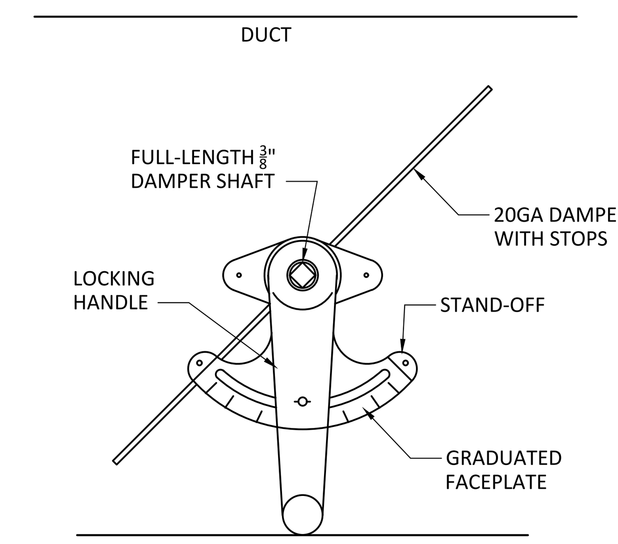
1 M3.2 DETAIL - AIR TERMINAL INSTALLATION
NOT TO SCALE



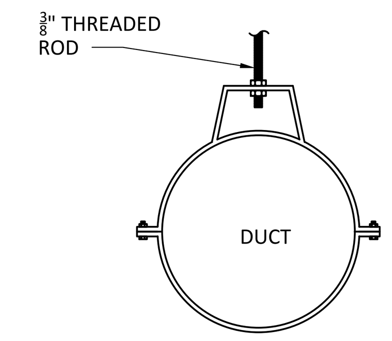
2 M3.2 DETAIL - TERMINAL UNIT SUPPORT
NOT TO SCALE



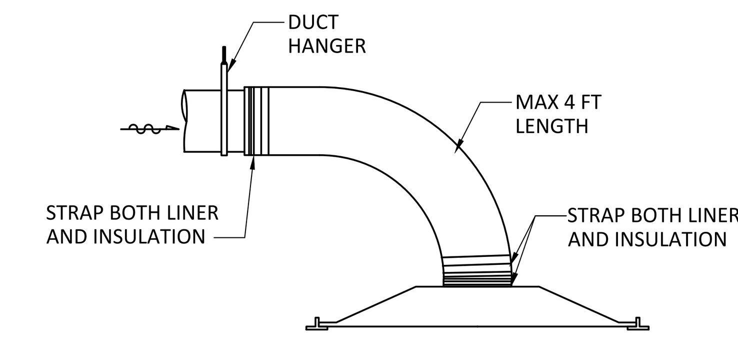
3 M3.2 DETAIL - TAKE-OFF DUCT
NOT TO SCALE



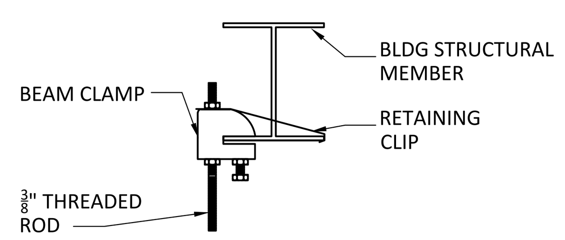
4 M3.2 DETAIL - AIR VOLUME DAMPER
NOT TO SCALE



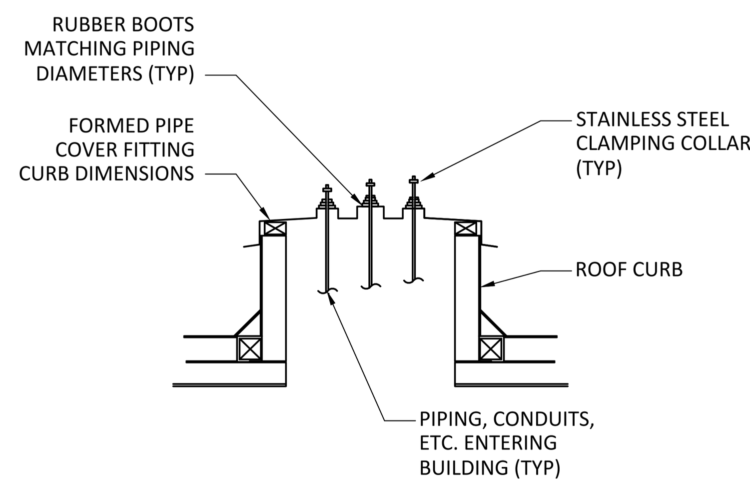
5 M3.2 DETAIL - EXPOSED DUCT HANGER
NOT TO SCALE



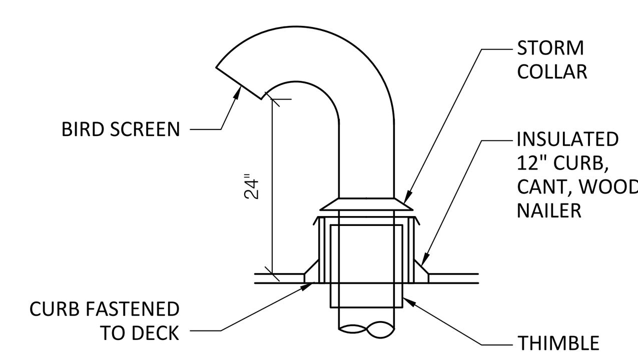
6 M3.2 DETAIL - SUPPLY AIR DEVICE
NOT TO SCALE



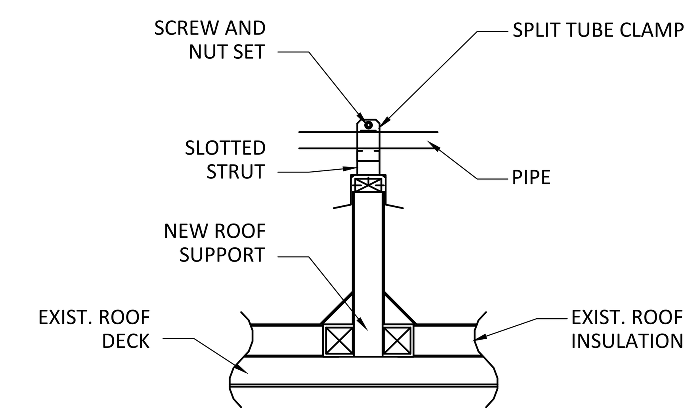
7 M3.2 DETAIL - TYPICAL HANGERS AND ROD
NOT TO SCALE



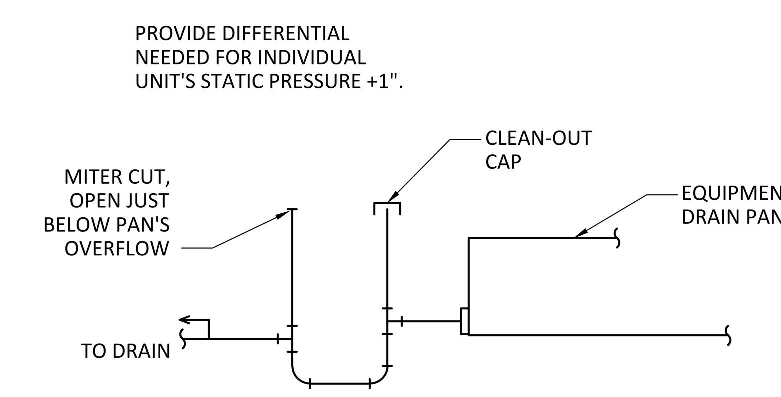
8 M3.2 DETAIL - PIPING PENETRATION AT ROOF
NOT TO SCALE



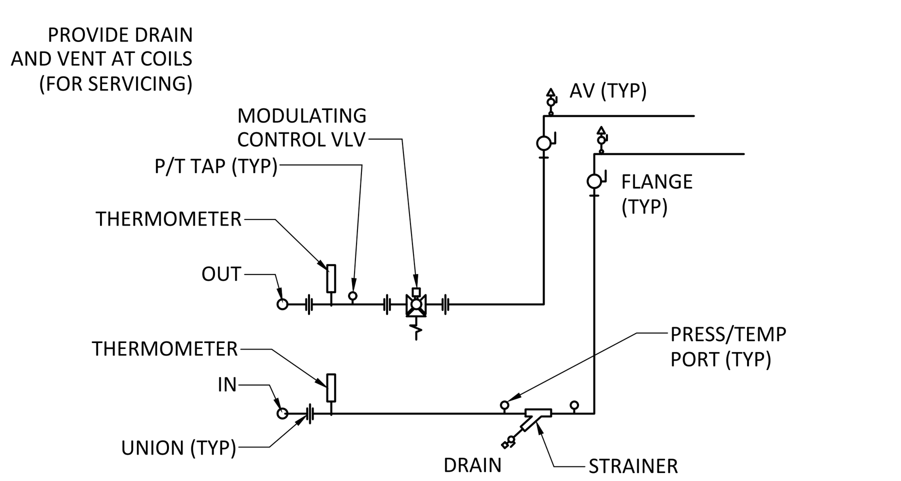
9 M3.2 DETAIL - TYPICAL DUCT DISCHARGE ROOF
NOT TO SCALE



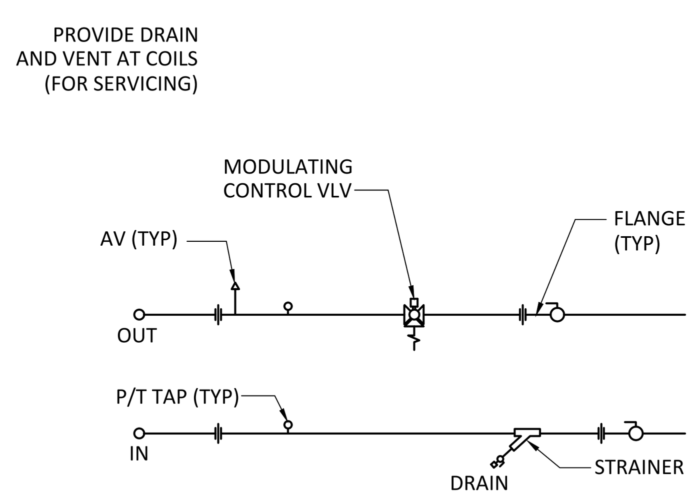
10 M3.2 DETAIL - PIPING SUPPORT ON ROOF
NOT TO SCALE



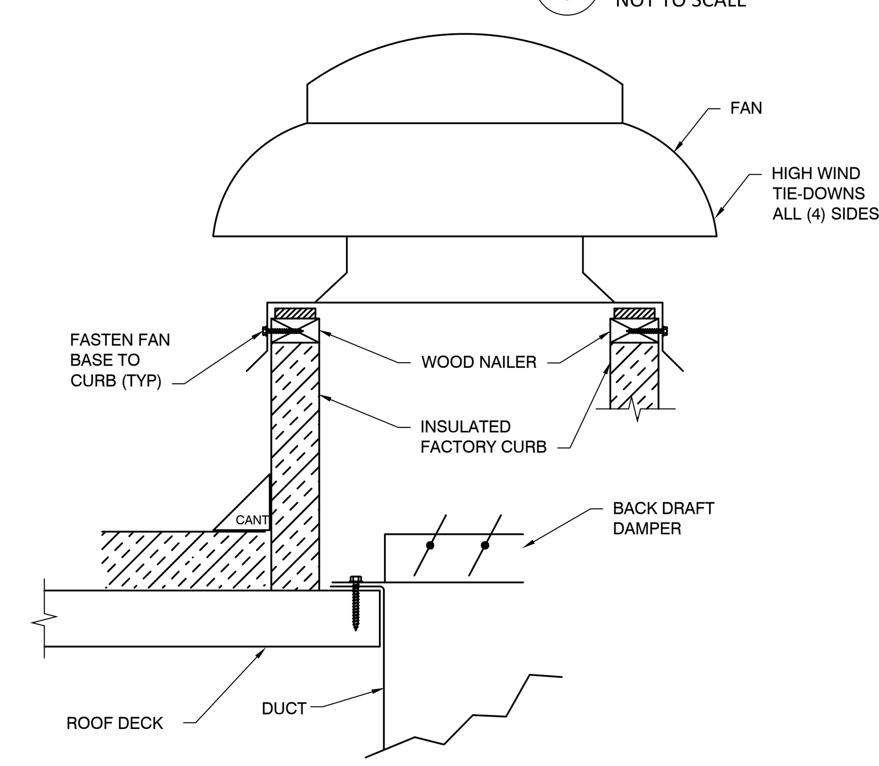
11 M3.2 DETAIL - CONENSATE DRAINAGE PIPING
NOT TO SCALE



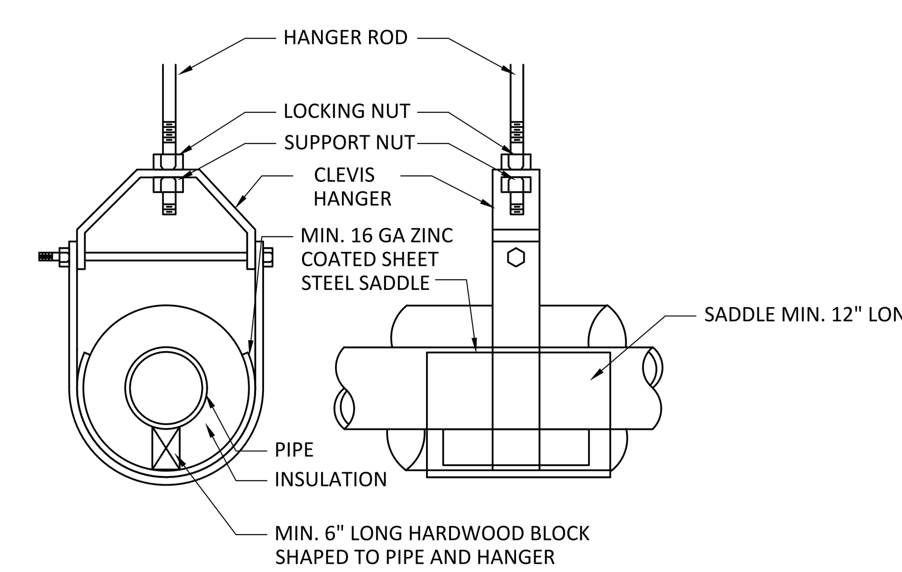
12 M3.2 DETAIL - TYPICAL WATER PIPING AT COILS
NOT TO SCALE



13 M3.2 DETAIL - WATER PIPING AT TERMINAL UNIT COILS
NOT TO SCALE

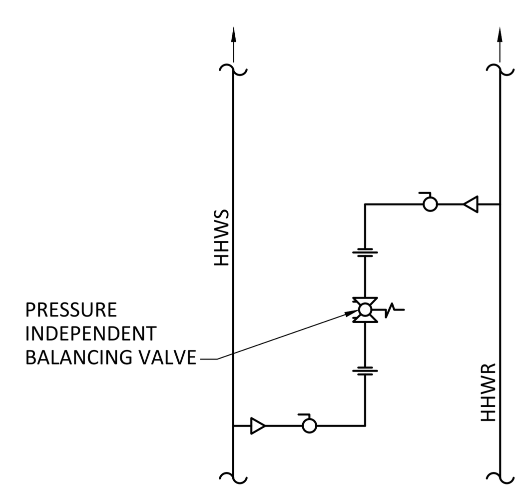


14 M3.2 DETAIL - ROOF MOUNTED EXHAUST FAN
NOT TO SCALE

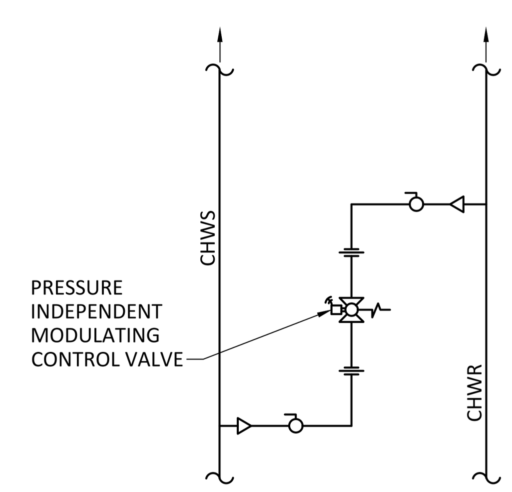


15 M3.2 DETAIL - PIPING HANGER
NOT TO SCALE

C



16 M3.2 DETAIL - HEATING HOT WATER MIN. FLOW BYPASS
NOT TO SCALE



17 M3.2 DETAIL - CHILLED WATER MIN. FLOW BYPASS
NOT TO SCALE

LEGEND

AV - AIR VENT

LEGEND

MODULATING TWO-WAY CONTROL VALVE, PRESSURE INDEPENDENT

K4
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REVISIONS / SUBMISSIONS

NO.	DESCRIPTION	DATE
	BID ISSUE	01/04/23
C	ADDENDUM C	01/27/23

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HVAC DETAILS AND DIAGRAMS

Drawn By:	TK, BBJ, MW
Scale:	AS NOTED
Job No.:	22-2038

M3.2

ELECTRIC RADIANT CEILING HEATERS SCHEDULE

TAG	DESCRIPTION	ROOM SERVED	CAPACITY (WATTS)	DIMENSIONS (INCHES)	MOUNTING	ELECTRICAL VOLTAGE	ELECTRICAL PHASE	REFERENCED MANUFACTURER	REFERENCED MODEL	NOTES
EH-1	CEILING MOUNTED RADIANT HEATER	TOILET 212	375	24 x 24 x 1	LAY-IN	120	1	BERKO	CP SERIES	A, B
EH-2	CEILING MOUNTED RADIANT HEATER	TOILET 213	375	24 x 24 x 1	LAY-IN	120	1	BERKO	CP SERIES	A, B

NOTES
- A FACTORY POWER RELAY AND SWITCH
- B FACTORY WALL MOUNTED THERMOSTAT, CONCEALED ADJUSTMENT

PACKAGED GAS-ELECTRIC ROOFTOP UNITS SCHEDULE

		FANS											DIMENSIONS						
TAG	DESCRIPTION	SUPPLY FANS (QUAN)	SUPPLY AIRFLOW (CFM)	OUTDOOR AIRFLOW (MIN CFM)	FAN MOTOR (BHP/NHP)	ESP (INCH WC)	SPEED (RPM)	EXHAUST FANS (QUAN)	EXHAUST AIRFLOW (MAX CFM)	FAN MOTOR (BHP/NHP)	ESP (INCH WC)	SPEED (RPM)	LENGTH (IN)	WIDTH (IN)	HEIGHT (IN)	INSTALLED WEIGHT (LBS)	FILTERS QUAN	FILTERS SIZES (IN)	FILTERS MERV RATING
RTU-1	MULTI-ZONE VAV PACKAGED ROOFTOP UNIT, SOUTH, SECOND FLOOR	1	4,610	550	3.3 / 8.0	1.0	2,070	1	4,000	1.7 / 4.0	.5	1,600	91	96	57	2,410	6	24 X 18	14
RTU-2	MULTI-ZONE VAV PACKAGED ROOFTOP UNIT, WEST, SECOND FLOOR	1	4,450	480	3.1 / 8.0	1.0	2,030	1	4,000	1.7/4.0	.5	1,550	91	96	57	2,410	6	24 X 18	14

	ELECTRICAL			COOLING										HEATING						REFERENCED PRODUCT	
TAG	VOLTAGE	MCA	MOCP	COMPRESSORS QUAN	COMPRESSORS TYPE	REFRIGERNT TYPE	ROWS (QUANT)	APD (IN)	AIRFLOW (CFM)	SENSIBLE (BTUH)	LATENT (BTUH)	LEAVING AIR (DB F / WB F)	EFFICIENCY EER	BURNER TYPE	GAS PRESSURE (MIN / MAX - IN WC)	INPUT (MAX - BTUH)	OUTPUT (MAX - BTUH)	TURNDOWN RATIO	LEAVING AIR (F)	MANUFACTURER	MODEL
RTU-1	208 - 3PH	67.3	80	2	SCROLL	R-410A	4	0.32	4,610	108,070	44,600	56.6/56.5	11.2	MODULATING	5 / 7	200,000	160,000	10:1	92	DAIKIN	DPS012A
RTU-2	208 - 3PH	67.3	80	2	SCROLL	R-410A	4	0.32	4,610	106,100	45,800	56.6/56.5	11.2	MODULATING	5 / 7	200,000	160,000	10:1	93	DAIKIN	DPS012A

NOTES

FACTORY FULL PERIMETER INSULATED CURB
BOTTOM DISCHARGE, BOTTOM RETURN
100% ECONOMIZER WITH ENTHALPY BASED CONTROL
AIRFOIL EXHAUST FAN
COOLING PERFORMANCE BASIS OF 95 F AMBIENT
TWO CONDENSER FANS
FACTORY CURB, CLIPS AND FASTENERS, PROFESSIONAL ENGINEER CERTIFIED, FOR WIND RATING
OUTDOOR AIRFLOW MONITOR
FACTORY NON-FUSED SERVICE DISCONNECT
115 V CONVENIENCE OUTLET, UNIT POWERED
DUCT HIGH STATIC PRESSURE LIMIT SWITCH
BACNET/MST COMMUNICATION CARD

C

CHILLED WATER PUMPS SCHEDULE

TAG	DESCRIPTION	SYSTEM SERVED	FLOW (GPM)	HEAD (FT)	BHP	MOTOR HP	RPM	FLUID	INLET - OUTLET (INCHES)	FLUID TEMP (F)	ELECTRICAL VOLTAGE	ELECTRICAL PHASE	ELECTRICAL AMP	DRIVE	REFERENCED MANUFACTURER	REFERENCED MODEL	NOTES
CWP-1	END SUCTION PUMP	CHILLED WATER	140	105	5.8	10	1,800	GLYCOL MIX - 30%	3 X 2	44	208	3	30.8	VFD	B & G	SERIES E-1532-2EB	A, B, C
CWP-2	END SUCTION PUMP	CHILLED WATER	140	105	5.8	10	1,800	GLYCOL MIX - 30%	3 X 2	44	208	3	30.8	VFD	B & G	SERIES E-1532-2EB	A, B, C

NOTES
- A PROVIDE FACTORY SUCTION DIFFUSER
- B MINIMUM 66% DUTY POINT EFFICIENCY
- C 215J MOTOR FRAME

VFD SCHEDULE

TAG	DESCRIPTION	SERVES	LOCATION	VOLTAGE AC	HP	DISCONNECT	FUSING	BYPASS	REFERENCED MANUFACTURER	REFERENCED MODEL	NOTES
VFD-1	VARIABLE FREQUENCY DRIVE	LASER EXHAUST FAN LEF-1	WALL-MOUNTED - GARAGE - ROOM 129	208	2	YES	YES	NO	ABB	ACH580-PDR-07A5-2	A, B
VFD-2	VARIABLE FREQUENCY DRIVE	LASER EXHAUST FAN LEF-2	WALL-MOUNTED - GARAGE - ROOM 129	208	2	YES	YES	NO	ABB	ACH580-PDR-07A5-2	A, B
VFD-3	VARIABLE FREQUENCY DRIVE	HEATING HOT WATER PUMP HWP-1	WALL-MOUNTED - MECHANICAL ROOM 123	208	3	YES	YES	NO	ABB	ACH580-PDR-10A6-2	A, C
VFD-4	VARIABLE FREQUENCY DRIVE	HEATING HOT WATER PUMP HWP-2	WALL-MOUNTED - MECHANICAL ROOM 123	208	3	YES	YES	NO	ABB	ACH580-PDR-10A6-2	A, C
VFD-5	VARIABLE FREQUENCY DRIVE	CHILLED WATER PUMP CWP-1	WALL-MOUNTED - MECHANICAL ROOM 123	208	10	YES	YES	NO	ABB	ACH580-PDR-031A-2	A, C
VFD-6	VARIABLE FREQUENCY DRIVE	CHILLED WATER PUMP CWP-1	WALL-MOUNTED - MECHANICAL ROOM 123	208	10	YES	YES	NO	ABB	ACH580-PDR-031A-2	A, C

NOTES
- A BTL LISTED FOR BACNET MS/TP
- B MANUAL SPEED ADJUSTMENT AND SET
- C AUTOMATED CONTROL FROM BAS

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HVAC SCHEDULES

Drawn By: TK, BBJ, MW
Scale: AS NOTED
Job No.: 22-2038

M4.3

Filename : M4.3_Mech Sched.dwg   Plot Date : Jan. 27, 2023 8:22pm

Ventillation Table
OMC 2017, ASHRAE 62.1

Diversity (D)	
sum of calculated occupants (Pz)	61
actual occupancy (Ps)	61
resulting diversity (D)	100%

Zone air distrib effectiveness (Ez)
look-up from Table 6-2.2.2

system type description	Ez selected
overhead S and R	0.8

System ventillation effectiveness (Ev)
look-up from Table 6-2.5.2

Maximum Zp	Ev selected
28.3%	0.8

System Greene County Xenia Library Renovation, Xenia, Ohio

ASHRAE 62.1-2016

Building Floor	Room name	Unit tag	Zone SF (Az)	space use description	NOTE	Activity - selected from table 6-2.2.1	# people/ 1000 sf	# people-calculated (Pz)	actual people (Ps) - (supercedes Pz)	cfm/person (Rp)	cfm/sf (Ra)	Exh rate Table 6-5 (cfm/sf)	Exh per fixt Table 6-5 (cfm-ea)	No of fixtures	Supply air cfm - zone primary airflow Vpz - Design	resulting OA cfm - people (Pz x Rp)	resulting OA cfm - area (Az x Ra)	Outdoor air req'd at breathing zone (Vbz)	resulting exh cfm	Outdoor air flow at zone (Voz)	Zone primary OA fraction (Zp)	Uncorrected outdoor air from system (Vou)	System total outdoor air intake (Vot)
1st	Stacks-south perimeter	AHU-1	3,790	stacks		libraries	10	38	38	5.0	0.06	0	0	0	4,700	190	228	418	0	522.5	11.1%	418	523
	Stacks-core portion		2,010	stacks		libraries	10	21	21	5.0	0.06	0	0	0	1,000	105	121	226	0	282.5	28.3%	226	283
	vestibule		180	common		corridors	0	0	0	0.0	0.06	0	0	0	500	0	11	11	0	13.75	2.8%	11	14
	study		175	private room		office space	5	1	1	5.0	0.06	0	0	0	460	5	11	16	0	20	4.3%	16	20
	study		145	private room		office space	5	1	1	5.0	0.06	0	0	0	280	5	9	14	0	17.5	6.3%	14	18
	water		96	util		- -	0	0	0	0.0	0.06	0	0	0	50	0	6	6	0	7.5	15.0%	6	8
	SUMS		6,396					61	61						6,990				0			691	**864**

Ventillation Table
OMC 2017, ASHRAE 62.1

Diversity (D)	
sum of calculated occupants (Pz)	93
actual occupancy (Ps)	119
resulting diversity (D)	128%

Zone air distrib effectiveness (Ez)
look-up from Table 6-2.2.2

system type description	Ez selected
overhead S and R	0.8

System ventillation effectiveness (Ev)
look-up from Table 6-2.5.2

Maximum Zp	Ev selected
29.5%	0.8

System Greene County Xenia Library Renovation, Xenia, Ohio

ASHRAE 62.1-2016

Building Floor	Room name	Unit tag	Zone SF (Az)	space use description	NOTE	Activity - selected from table 6-2.2.1	# people/ 1000 sf	# people-calculated (Pz)	actual people (Ps) - (supercedes Pz)	cfm/person (Rp)	cfm/sf (Ra)	Exh rate Table 6-5 (cfm/sf)	Exh per fixt Table 6-5 (cfm-ea)	No of fixtures	Supply air cfm - zone primary airflow Vpz - Design	resulting OA cfm - people (Pz x Rp)	resulting OA cfm - area (Az x Ra)	Outdoor air req'd at breathing zone (Vbz)	resulting exh cfm	Outdoor air flow at zone (Voz)	Zone primary OA fraction (Zp)	Uncorrected outdoor air from system (Vou)	System total outdoor air intake (Vot)
1st	Youth stack	AHU-2	900	stacks		libraries	10	9	9	5.0	0.06	0	0	0	420	45	54	99	0	123.75	29.5%	127	158
	youth (infill) stack		1,162	stacks		libraries	10	12	12	5.0	0.06	0	0	0	2,100	60	70	130	0	162.5	7.7%	166	208
	Youth stacks (added area)		155	stacks		libraries	10	2	2	5.0	0.06	0	0	0	450	10	10	20	0	25	5.6%	26	32
	youth workroom		432	activity-work		libraries	10	5	8	5.0	0.06	0	0	0	410	40	26	66	0	82.5	20.1%	84	106
	womens rr		144	common		- -	0	0	0	0.0	0.06	0	75	2	40	0	9	9	150	11.25	28.1%	12	14
	mens rr		144	common		- -	0	0	0	0.0	0.06	0	75	2	40	0	9	9	150	11.25	28.1%	12	14
	corridor		660	common		corridors	0	0	0	0.0	0.06	0	0	0	180	0	40	40	0	50	27.8%	51	64
	storage		115	storage		corridors	0	0	0	0.0	0.06	0	0	0	60	0	7	7	0	8.75	14.6%	9	11
	storage		208	storage		corridors	0	0	0	0.0	0.06	0	0	0	200	0	13	13	0	16.25	8.1%	17	21
	Meeting		1,290	meeting		conference/meeting	50	65	88	5.0	0.06	0	0	0	1,740	440	78	378	0	472.5	27.2%	484	605
1st	storage-IT		25	storage		corridors	0	0	0	0.0	0.06	0	0	0	60	0	2	2	0	2.5	4.2%	3	3
	SUMS		5,235					93	119						5,700				300			989	**1,236**

Ventillation Table
OMC 2017, ASHRAE 62.1

Diversity (D)	
sum of calculated occupants (Pz)	33
actual occupancy (Ps)	33
resulting diversity (D)	100%

Zone air distrib effectiveness (Ez)
look-up from Table 6-2.2.2

system type description	Ez selected
overhead S and R	0.8

System ventillation effectiveness (Ev)
look-up from Table 6-2.5.2

Maximum Zp	Ev selected
29.6%	0.8

System Greene County Xenia Library Renovation, Xenia, Ohio

ASHRAE 62.1-2016

Building Floor	Room name	Unit tag	Zone SF (Az)	space use description	NOTE	Activity - selected from table 6-2.2.1	# people/ 1000 sf	# people-calculated (Pz)	actual people (Ps) - (supercedes Pz)	cfm/person (Rp)	cfm/sf (Ra)	Exh rate Table 6-5 (cfm/sf)	Exh per fixt Table 6-5 (cfm-ea)	No of fixtures	Supply air cfm - zone primary airflow Vpz - Design	resulting OA cfm - people (Pz x Rp)	resulting OA cfm - area (Az x Ra)	Outdoor air req'd at breathing zone (Vbz)	resulting exh cfm	Outdoor air flow at zone (Voz)	Zone primary OA fraction (Zp)	Uncorrected outdoor air from system (Vou)	System total outdoor air intake (Vot)
1st	Staff workroom	AHU-3	1,850	work-stacks		libraries	10	19	19	5.0	0.06	0	0	0	900	95	111	206	0	257.5	28.6%	206	258
	Staff helpdesk area		710	work-stacks		libraries	10	8	8	5.0	0.06	0	0	0	350	40	43	83	0	103.75	29.6%	83	104
	office		100	private office		office space	5	1	1	5.0	0.06	0	0	0	115	5	6	11	0	13.75	12.0%	11	14
	office		100	private office		office space	5	1	1	5.0	0.06	0	0	0	115	5	6	11	0	13.75	12.0%	11	14
	office		180	private office		office space	5	1	1	5.0	0.06	0	0	0	115	5	11	16	0	20	17.4%	16	20
	office		156	private office		office space	5	1	1	5.0	0.06	0	0	0	155	5	10	15	0	18.75	12.1%	15	19
	office		198	private office		office space	5	1	1	5.0	0.06	0	0	0	235	5	12	17	0	21.25	9.0%	17	21
	vestibule-books		295	common		corridors	0	0	0	0.0	0.06	0	0	0	210	0	18	18	0	22.5	10.7%	18	23
	restroom		94	common		- -	0	0	0	0.0	0.06	0	75	1	30	0	6	6	75	7.5	25.0%	6	8
	corridor		365	common		- -	0	0	0	0.0	0.06	0	0	0	95	0	22	22	0	27.5	28.9%	22	28
	restroom		108	common		- -	0	0	0	0.0	0.06	0	75	1	50	0	7	7	75	8.75	17.5%	7	9
	storage		345	working storage		occupiable dry storage	2	1	1	5.0	0.06	0	0	0	330	5	21	26	0	32.5	9.8%	26	33
	SUMS		4,501					33	33						2,700				150			438	**548**

Ventillation Table
OMC 2017, ASHRAE 62.1

Diversity (D)	
sum of calculated occupants (Pz)	58
actual occupancy (Ps)	53
resulting diversity (D)	91%

Zone air distrib effectiveness (Ez)
look-up from Table 6-2.2.2

system type description	Ez selected
overhead S and R	0.8

System ventillation effectiveness (Ev)
look-up from Table 6-2.5.2

Maximum Zp	Ev selected
43.8%	0.7

System Greene County Xenia Library Renovation, Xenia, Ohio

ASHRAE 62.1-2016

Building Floor	Room name	Unit tag	Zone SF (Az)	space use description	NOTE	Activity - selected from table 6-2.2.1	# people/ 1000 sf	# people-calculated (Pz)	actual people (Ps) - (supercedes Pz)	cfm/person (Rp)	cfm/sf (Ra)	Exh rate Table 6-5 (cfm/sf)	Exh per fixt Table 6-5 (cfm-ea)	No of fixtures	Supply air cfm - zone primary airflow Vpz - Design	resulting OA cfm - people (Pz x Rp)	resulting OA cfm - area (Az x Ra)	Outdoor air req'd at breathing zone (Vbz)	resulting exh cfm	Outdoor air flow at zone (Voz)	Zone primary OA fraction (Zp)	Uncorrected outdoor air from system (Vou)	System total outdoor air intake (Vot)
1st	Makers Space	AHU-4	1,560	production-workroom	A	media center	25	39	35	10.0	0.12	0	1,135	1	2,360	350	188	538	1,135	672.5	28.5%	492	702
	training		225	classroom		classrooms	35	8	8	10.0	0.12	0	0	0	330	80	27	107	0	133.75	40.5%	98	140
	sound		117	private-work		media center	25	3	2	10.0	0.12	0	0	0	100	20	15	35	0	43.75	43.8%	32	46
	storage		50	storage		corridors	0	0	0	0.0	0.06	0	0	0	20	0	3	3	0	3.75	18.8%	3	4
	video-photo		225	private-work		photo studio	10	3	3	5.0	0.12	0	0	0	230	15	27	42	0	52.5	22.8%	38	55
	workroom		192	work-makers		media center	25	5	5	10.0	0.12	0	0	0	220	50	24	74	0	92.5	42.0%	68	97
	storage		80	storage		corridors	0	0	0	0.0	0.06	0	0	0	20	0	5	5	0	6.25	31.3%	5	7
	corridor outside Makers		625	common		corridors	0	0	0	0.0	0.06	0	0	0	120	0	38	38	0	47.5	39.6%	35	50
	SUMS		3,074					58	53						3,400				1,135			278	**1,099**

	NOTES
A	Exhaust required from owner equipment
B	
C	

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COMPLETE RENOVATION/MECHANICAL UPGRADES:
Greene County Public Library
XENIA COMMUNITY LIBRARY
76 EAST MARKET STREET
XENIA, OH 45385

REVISIONS / SUBMISSIONS		
NO.	DESCRIPTION	DATE
	BID ISSUE	01/04/23
C	ADDENDUM C	01/27/23

PRELIMINARY BID
NOT FOR
CONSTRUCTION

HVAC
SCHEDULES

Drawn By: TK, BBJ, MW
Scale: AS NOTED
Job No.: 22-2038

M4.5

File Location : C:\Users\conda\Dropbox\projects\Enhance Engineering\20220823 Xenia - Green County Library\
Filename : M4.5_Mech Sched.dwg   Plot Date : Jan. 28, 2023 1:44pm

Ventillation Table
OMC 2017, ASHRAE 62.1

Diversity (D)	
sum of calculated occupants (Pz)	52
actual occupancy (Ps)	52
resulting diversity (D)	100%

Zone air distrib effectiveness (Ez)

look-up from Table 6-2.2.2

system type description	Ez selected
overhead S and R	0.8

System ventillation effectiveness (Ev)

look-up from Table 6-2.5.2

Maximum Zp	Ev selected
34.4%	0.8

System Greene County Xenia Library Renovation, Xenia, Ohic

ASHRAE 62.1-2016

Building Floor	Room name	Unit tag	Zone SF (Az)	space use description	NOTE	Activity - selected from table 6-2.2.1	# people/ 1000 sf - table 6-1	# people- calculated (Pz)	actual people (Ps) - (supercedes Pz)	cfm/person (Rp)	cfm/sf (Ra)	Exh rate Table 6-5 (cfm/sf)	Exh per fixt Table 6-5 (cfm-ea)	No of fixtures	Supply air cfm - zone primary airflow Vpz - Design	resulting OA cfm - people (Pz x Rp)	resulting OA cfm - area (Az x Ra)	Outdoor air req'd at breathing zone (Vbz)	resulting exh cfm	Outdoor air flow at zone (Voz)	Zone primary OA fraction (Zp)	Uncorrected outdoor air from system (Vou)	System total outdoor air intake (Vot)
2nd	Greene County room	AHU-5	1,912	work-stacks		libraries	10	20	20	5.0	0.06	0	0	0	1,050	100	115	215	0	268.75	25.6%	215	269
	Open office		578	open office		office space	5	3	3	5.0	0.06	0	0	0	230	15	35	50	0	62.5	27.2%	50	63
	corridor		384	common		corridors	0	0	0	0.0	0.06	0	0	0	140	0	24	24	0	30	21.4%	24	30
	workroom		390	work		libraries	10	4	4	5.0	0.06	0	0	0	160	20	24	44	0	55	34.4%	44	55
	corridor-inner		133	common		corridors	0	0	0	0.0	0.06	0	0	0	50	0	8	8	0	10	20.0%	8	10
	storage		520	working - storage		occupiable dry storage	2	2	2	5.0	0.06	0	0	0	170	10	32	42	0	52.5	30.9%	42	53
	storage		108	storage		corridors	0	0	0	0.0	0.06	0	0	0	50	0	7	7	0	8.75	17.5%	7	9
	office		216	private office		office space	5	2	2	5.0	0.06	0	0	0	300	10	13	23	0	28.75	9.6%	23	29
	office		273	private office		office space	5	2	2	5.0	0.06	0	0	0	450	10	17	27	0	33.75	7.5%	27	34
	office		255	private office		office space	5	2	2	5.0	0.06	0	0	0	280	10	16	26	0	32.5	11.6%	26	33
	office		255	private office		office space	5	2	2	5.0	0.06	0	0	0	280	10	16	26	0	32.5	11.6%	26	33
	corridor		598	common		corridors	0	0	0	0.0	0.06	0	0	0	250	0	36	36	0	45	18.0%	36	45
	unisex rr		64	common		- -	0	0	0	0.0	0.06	0	75	1	50	0	4	4	75	5	10.0%	4	5
	unisex rr		64	common		- -	0	0	0	0.0	0.06	0	75	1	50	0	4	4	75	5	10.0%	4	5
	office		270	private office		office space	5	2	2	5.0	0.06	0	0	0	330	10	17	27	0	33.75	10.2%	27	34
	workroom		261	work		libraries	10	3	3	5.0	0.06	0	0	0	230	15	16	31	0	38.75	16.8%	31	39
	office		145	private office		office space	5	1	1	5.0	0.06	0	0	0	230	5	9	14	0	17.5	7.6%	14	18
	break room		323	staff gathering		breakrooms	25	9	9	5.0	0.06	0.5	0	0	540	45	20	65	162	81.25	15.0%	65	81
	SUMS		6,749					52	52						4,840				312			673	**841**

Ventillation Table
OMC 2017, ASHRAE 62.1

Diversity (D)	
sum of calculated occupants (Pz)	39
actual occupancy (Ps)	39
resulting diversity (D)	100%

Zone air distrib effectiveness (Ez)

look-up from Table 6-2.2.2

system type description	Ez selected
overhead S and R	0.8

System ventillation effectiveness (Ev)

look-up from Table 6-2.5.2

Maximum Zp	Ev selected
25.0%	0.8

System Greene County Xenia Library Renovation, Xenia, Ohio

ASHRAE 62.1-2016

Building Floor	Room name	Unit tag	Zone SF (Az)	space use description	NOTE	Activity - selected from table 6-2.2.1	# people/ 1000 sf - table 6-1	# people- calculated (Pz)	actual people (Ps) - (supercedes Pz)	cfm/person (Rp)	cfm/sf (Ra)	Exh rate Table 6-5 (cfm/sf)	Exh per fixt Table 6-5 (cfm-ea)	No of fixtures	Supply air cfm - zone primary airflow Vpz - Design	resulting OA cfm - people (Pz x Rp)	resulting OA cfm - area (Az x Ra)	Outdoor air req'd at breathing zone (Vbz)	resulting exh cfm	Outdoor air flow at zone (Voz)	Zone primary OA fraction (Zp)	Uncorrected outdoor air from system (Vou)	System total outdoor air intake (Vot)
2nd	Waiting	RTU-1	942	common		reception area	30	29	29	5.0	0.06	0	0	0	1,180	145	57	202	0	252.5	21.4%	202	253
	corridor		1,010	common		corridors	0	0	0	0.0	0.06	0	0	0	2,120	0	61	61	0	76.25	3.6%	61	76
	unisex rr		64	common		- -	0	0	0	0.0	0.06	0	75	1	20	0	4	4	75	5	25.0%	4	5
	office-corner		305	private office		office space	5	2	2	5.0	0.06	0	0	0	520	10	19	29	0	36.25	7.0%	29	36
	office		220	private office		office space	5	2	2	5.0	0.06	0	0	0	140	10	14	24	0	30	21.4%	24	30
	office		176	private office		office space	5	1	1	5.0	0.06	0	0	0	110	5	11	16	0	20	18.2%	16	20
	office		176	private office		office space	5	1	1	5.0	0.06	0	0	0	110	5	11	16	0	20	18.2%	16	20
	office		108	private office		office space	5	1	1	5.0	0.06	0	0	0	80	5	7	12	0	15	18.8%	12	15
	office		176	private office		office space	5	1	1	5.0	0.06	0	0	0	110	5	11	16	0	20	18.2%	16	20
	office		176	private office		office space	5	1	1	5.0	0.06	0	0	0	110	5	11	16	0	20	18.2%	16	20
	office		176	private office		office space	5	1	1	5.0	0.06	0	0	0	110	5	11	16	0	20	18.2%	16	20
	SUMS		3,529					39	39						4,610				75			412	**515**

Ventillation Table
OMC 2017, ASHRAE 62.1

Diversity (D)	
sum of calculated occupants (Pz)	64
actual occupancy (Ps)	47
resulting diversity (D)	73%

Zone air distrib effectiveness (Ez)

look-up from Table 6-2.2.2

system type description	Ez selected
overhead S and R	0.8

System ventillation effectiveness (Ev)

look-up from Table 6-2.5.2

Maximum Zp	Ev selected
30.0%	0.8

System Greene County Xenia Library Renovation, Xenia,

ASHRAE 62.1-2016

Building Floor	Room name	Unit tag	Zone SF (Az)	space use description	NOTE	Activity - selected from table 6-2.2.1	# people/ 1000 sf	# people- calculated (Pz)	actual people (Ps) - (supercedes Pz)	cfm/person (Rp)	cfm/sf (Ra)	Exh rate Table 6-5 (cfm/sf)	Exh per fixt Table 6-5 (cfm-ea)	No of fixtures	Supply air cfm - zone primary airflow Vpz - Design	resulting OA cfm - people (Pz x Rp)	resulting OA cfm - area (Az x Ra)	Outdoor air req'd at breathing zone (Vbz)	resulting exh cfm	Outdoor air flow at zone (Voz)	Zone primary OA fraction (Zp)	Uncorrected outdoor air from system (Vou)	System total outdoor air intake (Vot)
2nd	Conference	RTU-2	338	meeting		conference/meeting	50	17	17	5.0	0.06	0	0	0	1,290	85	21	106	0	132.5	10.3%	78	97
	storage		198	storage		corridors	0	0	0	0.0	0.06	0	0	0	155	0	12	12	0	15	9.7%	9	11
	Board room		725	meeting		conference/meeting	50	37	20	5.0	0.06	0	0	0	1,050	100	44	144	0	180	17.1%	106	132
	storage		225	storage		corridors	0	0	0	0.0	0.06	0	0	0	630	0	14	14	0	17.5	2.8%	10	13
	storage		198	working storqge		occupiable dry storage	2	1	1	5.0	0.06	0	0	0	115	5	12	17	0	21.25	18.5%	12	16
	workroom		740	work		libraries	10	8	8	5.0	0.06	0	0	0	500	40	45	85	0	106.25	21.3%	62	78
	office-IT		180	private office		office space	5	1	1	5.0	0.06	0	0	0	340	5	11	16	0	20	5.9%	12	15
	mens rr		155	common		- -	0	0	0	0.0	0.06	0	75	2	60	0	10	10	150	12.5	20.8%	7	9
	womens rr		155	common		- -	0	0	0	0.0	0.06	0	75	2	60	0	10	10	150	12.5	20.8%	7	9
	janitors		60	util		- -	0	0	0	0.0	0.06	0	50	1	50	0	4	4	50	5	10.0%	3	4
	corridor		792	common		corridors	0	0	0	0.0	0.06	0	0	0	200	0	48	48	0	60	30.0%	35	44
	SUMS		3,766					64	47						4,450				350			342	**428**

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COMPLETE RENOVATION/MECHANICAL UPGRADES:
Greene County Public Library
XENIA COMMUNITY LIBRARY
76 EAST MARKET STREET
XENIA, OH 45385

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NO.	DESCRIPTION	DATE
	BID ISSUE	01/04/23
C	ADDENDUM C	01/27/23

PRELIMINARY BID NOT FOR CONSTRUCTION

C

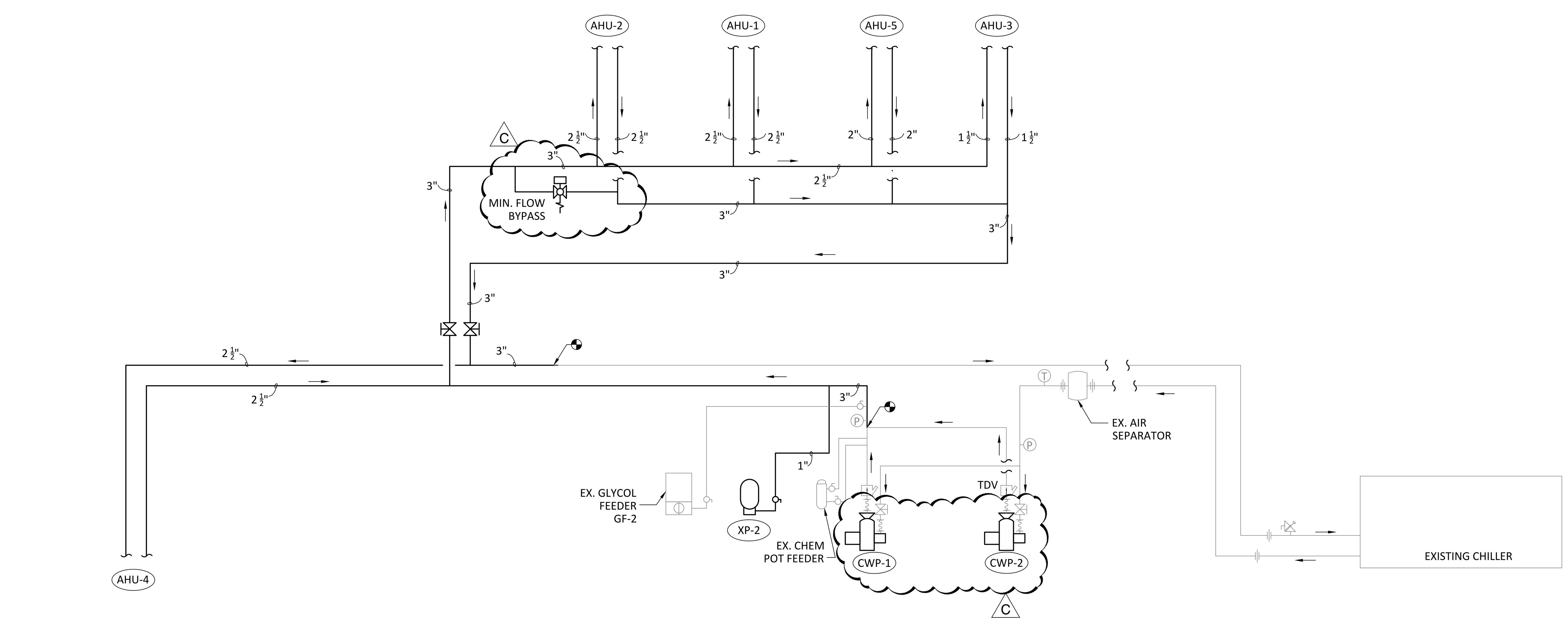
HVAC SCHEDULES

Drawn By:	TK, BBJ, MW
Scale:	AS NOTED
Job No.:	22-2038

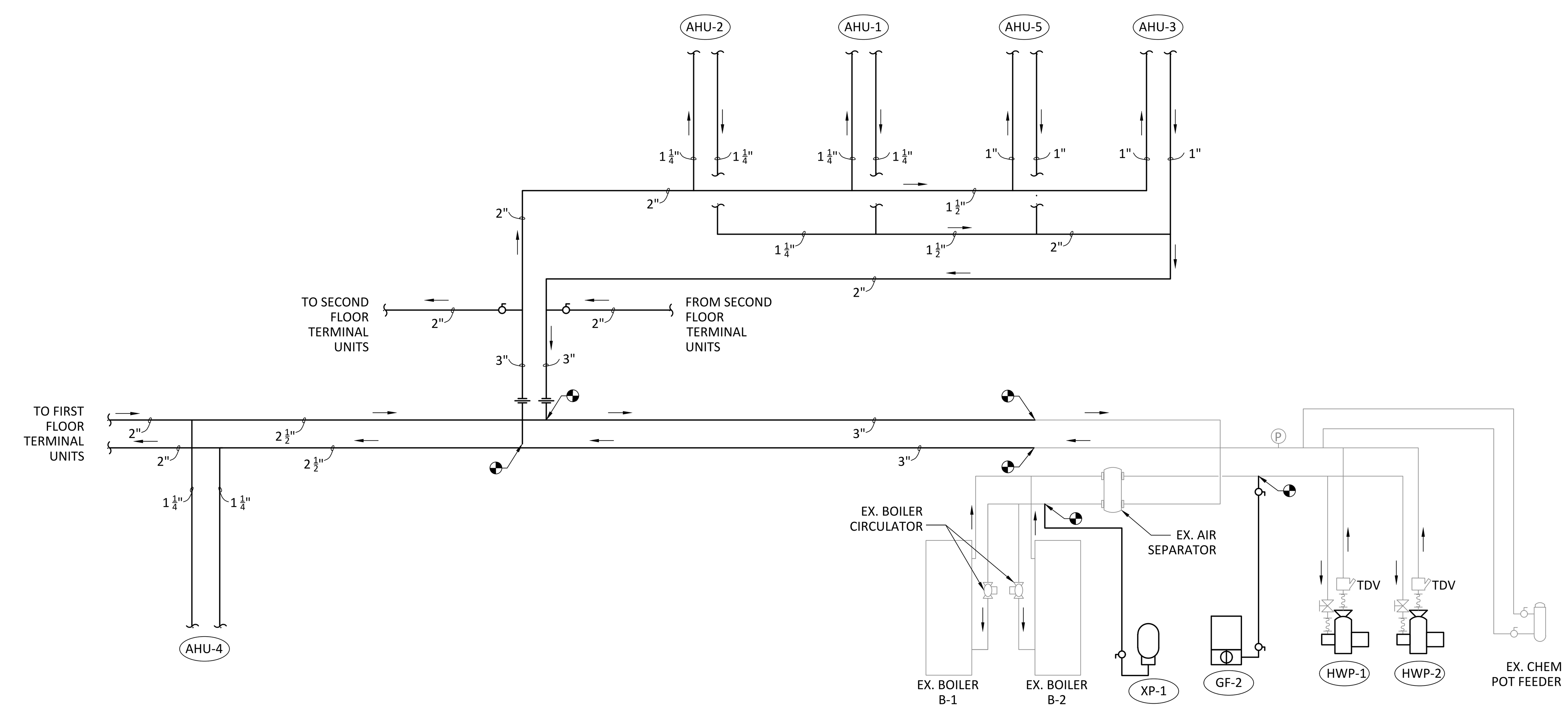
M4.6

File Location : C:\Users\conta\Dropbox\projects\Enhanse Engineering\20220823 Xenia - Green County Library\

Filename : M4.6_Mech Sched.dwg Plot Date : Jan. 28, 2023 1:47pm



1 M5.1 DETAIL - CHILLED WATER SYSTEM SCHEMATIC PIPING DIAGRAM
NOT TO SCALE



2 M5.1 DETAIL - HEATING HOT WATER SYSTEM SCHEMATIC PIPING DIAGRAM
NOT TO SCALE

LEGEND

- CONNECTION POINT, NEW TO EXISTING
- GATE VALVE
- BUTTERFLY VALVE
- FLANGE OR UNION

LEGEND

- FLEXIBLE CONNECTOR
- PRESSURE GAUGE
- TEMPERATURE

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COMPLETE RENOVATION/MECHANICAL UPGRADES:
Greene County Public Library
XENIA COMMUNITY LIBRARY
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XENIA, OH 45385

REVISIONS / SUBMISSIONS		
NO.	DESCRIPTION	DATE
	BID ISSUE	01/04/23
C	ADDENDUM C	01/27/23

PRELIMINARY BID
NOT FOR
CONSTRUCTION

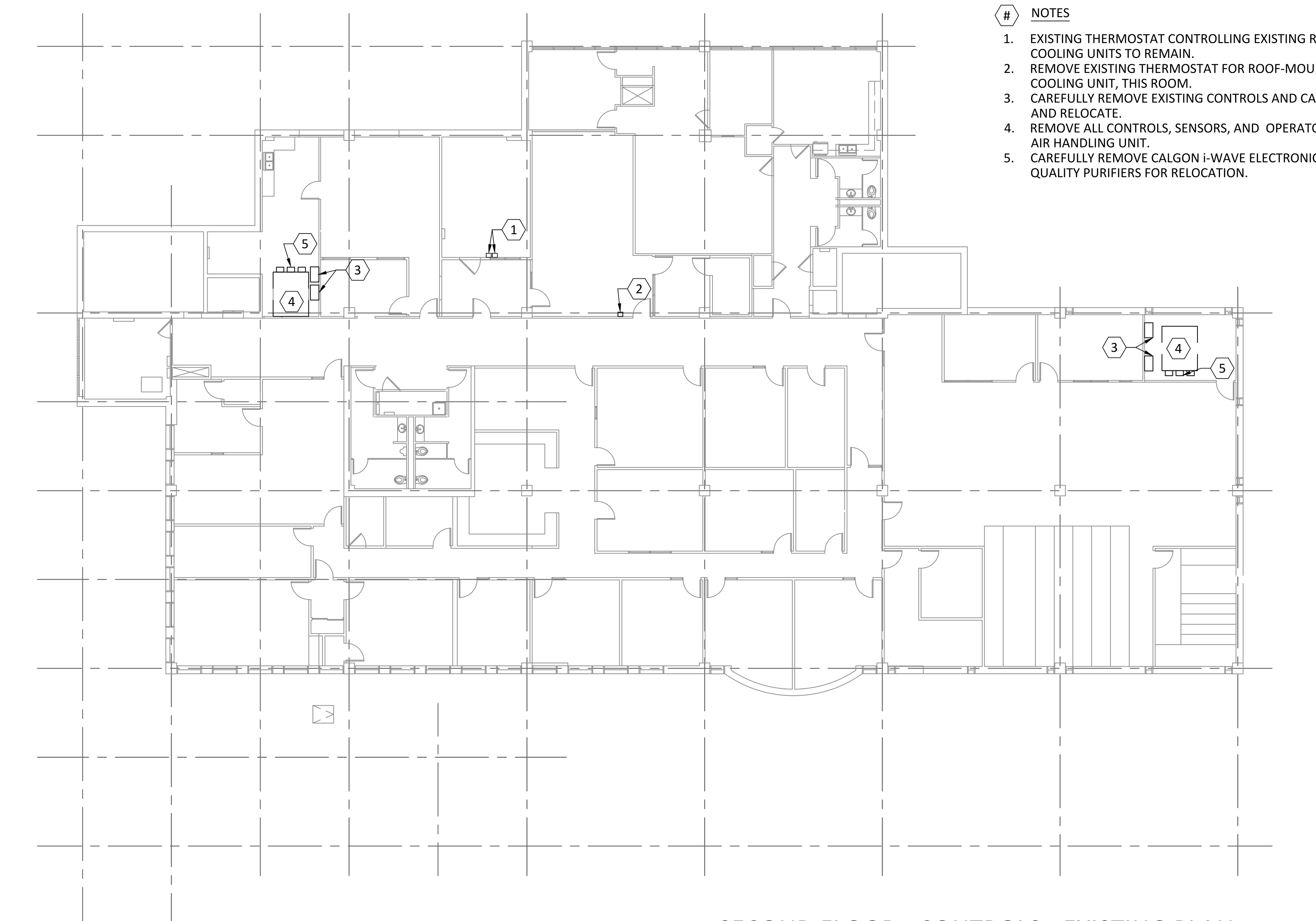
HVAC
PIPING
DIAGRAMS

Drawn By:	TK, BBJ, MW
Scale:	AS NOTED
Job No.:	22-2038

M5.1

File Location: C:\Users\conta\Dropbox\projects\Enhance Engineering\2022\0623 Xenia - Green County Library\

Filename : M5.1_Mech Piping Dia.dwg Plot Date : Jan. 27, 2023 8:20pm



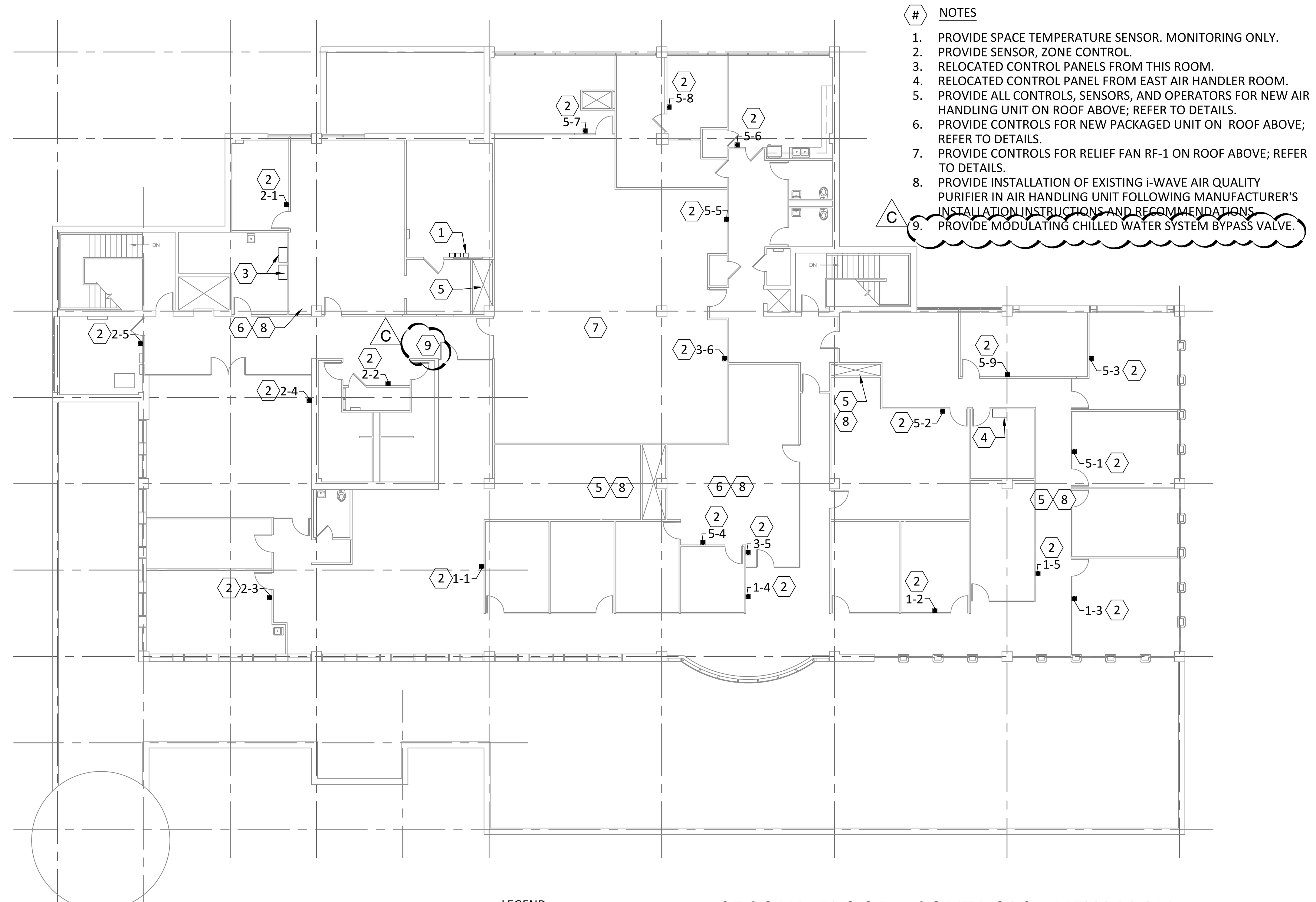
NOTES

1. EXISTING THERMOSTAT CONTROLLING EXISTING ROOM COOLING UNITS TO REMAIN.
2. REMOVE EXISTING THERMOSTAT FOR ROOF-MOUNTED COOLING UNIT, THIS ROOM.
3. CAREFULLY REMOVE EXISTING CONTROLS AND CABINETS AND RELOCATE.
4. REMOVE ALL CONTROLS, SENSORS, AND OPERATORS FOR AIR HANDLING UNIT.
5. CAREFULLY REMOVE CALGON i-WAVE ELECTRONIC AIR QUALITY PURIFIERS FOR RELOCATION.

C / M6.0 SECOND FLOOR - CONTROLS - EXISTING PLAN

Scale: 1/16" = 1'-0"

0 5' 10' 20' 30'



NOTES

1. PROVIDE SPACE TEMPERATURE SENSOR. MONITORING ONLY.
2. PROVIDE SENSOR, ZONE CONTROL.
3. RELOCATED CONTROL PANELS FROM THIS ROOM.
4. RELOCATED CONTROL PANEL FROM EAST AIR HANDLER ROOM.
5. PROVIDE ALL CONTROLS, SENSORS, AND OPERATORS FOR NEW AIR HANDLING UNIT ON ROOF ABOVE; REFER TO DETAILS.
6. PROVIDE CONTROLS FOR NEW PACKAGED UNIT ON ROOF ABOVE; REFER TO DETAILS.
7. PROVIDE CONTROLS FOR RELIEF FAN RF-1 ON ROOF ABOVE; REFER TO DETAILS.
8. PROVIDE INSTALLATION OF EXISTING i-WAVE AIR QUALITY PURIFIER IN AIR HANDLING UNIT FOLLOWING MANUFACTURER'S INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS.
9. PROVIDE MODULATING CHILLED WATER SYSTEM BYPASS VALVE.

LEGEND

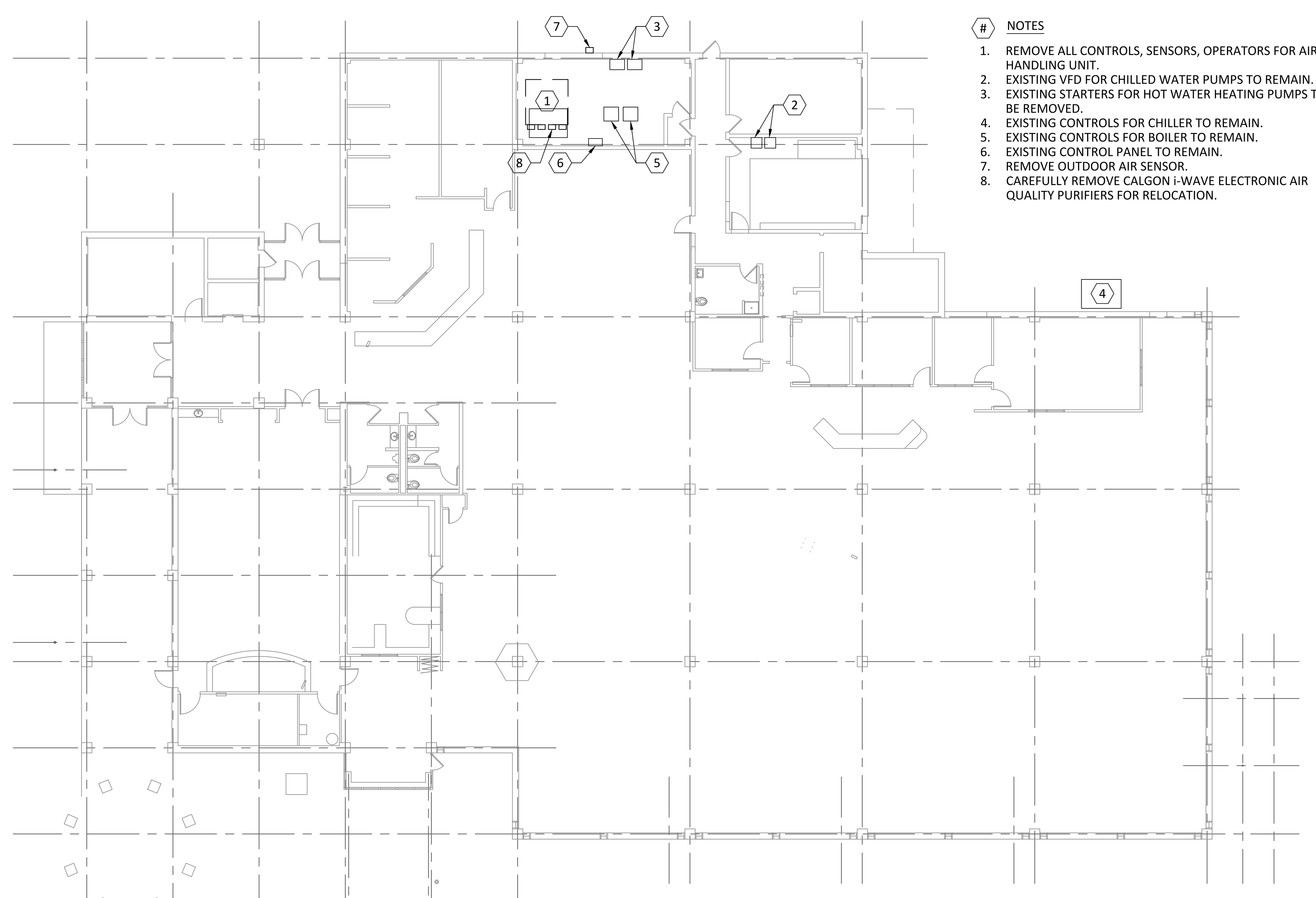
SPACE SENSOR

(X-X) ZONE IDENTIFIER

D / M6.0 SECOND FLOOR - CONTROLS - NEW PLAN

Scale: 1/16" = 1'-0"

0 5' 10' 20' 30'



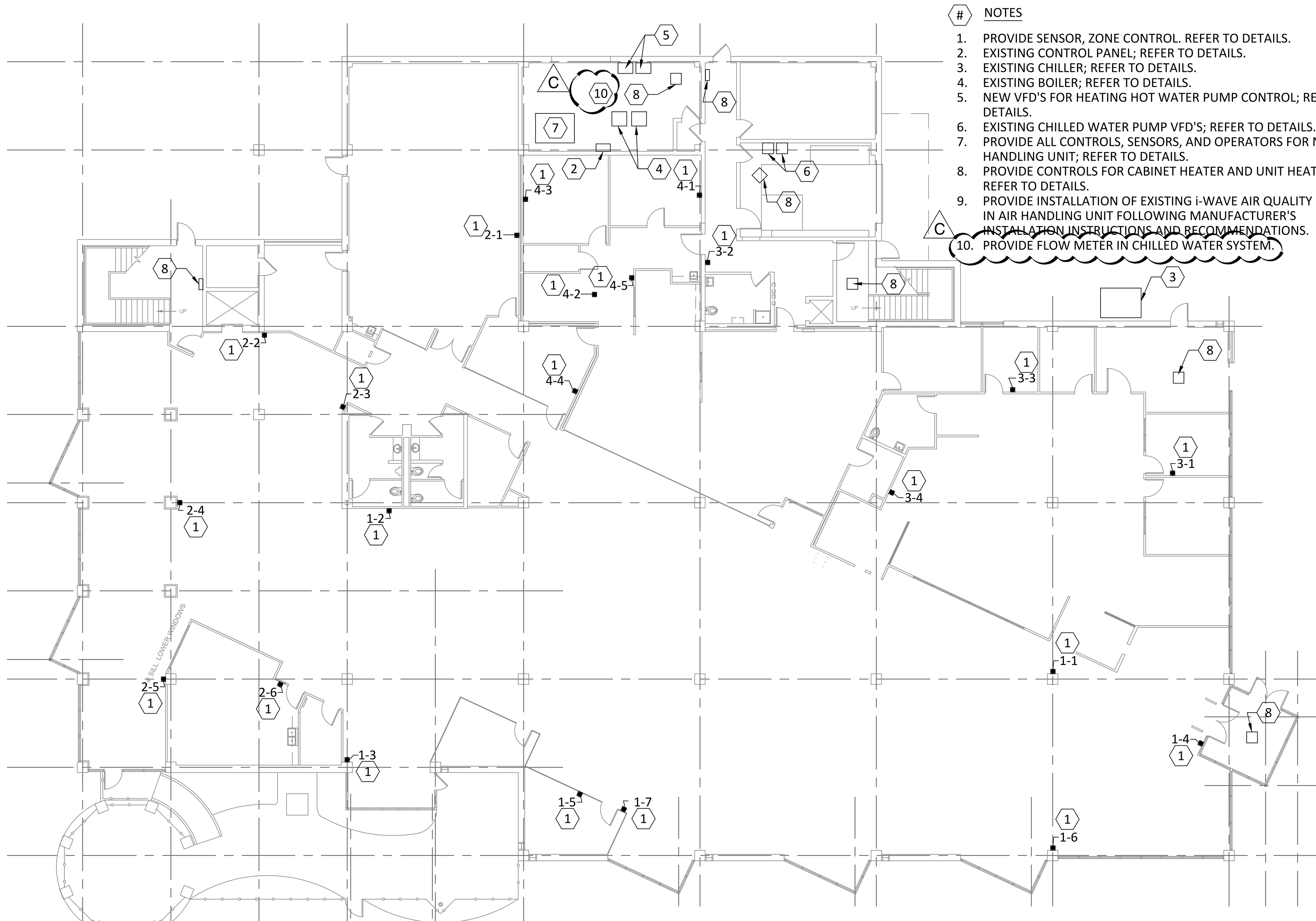
NOTES

1. REMOVE ALL CONTROLS, SENSORS, OPERATORS FOR AIR HANDLING UNIT.
2. EXISTING VFD FOR CHILLED WATER PUMPS TO REMAIN.
3. EXISTING STARTERS FOR HOT WATER HEATING PUMPS TO BE REMOVED.
4. EXISTING CONTROLS FOR CHILLER TO REMAIN.
5. EXISTING CONTROLS FOR BOILER TO REMAIN.
6. EXISTING CONTROL PANEL TO REMAIN.
7. REMOVE OUTDOOR AIR SENSOR.
8. CAREFULLY REMOVE CALGON i-WAVE ELECTRONIC AIR QUALITY PURIFIERS FOR RELOCATION.

A / M6.0 FIRST FLOOR - CONTROLS - EXISTING PLAN

Scale: 1/16" = 1'-0"

0 5' 10' 20' 30'



NOTES

1. PROVIDE SENSOR, ZONE CONTROL. REFER TO DETAILS.
2. EXISTING CONTROL PANEL; REFER TO DETAILS.
3. EXISTING CHILLER; REFER TO DETAILS.
4. EXISTING BOILER; REFER TO DETAILS.
5. NEW VFD'S FOR HEATING HOT WATER PUMP CONTROL; REFER TO DETAILS.
6. EXISTING CHILLED WATER PUMP VFD'S; REFER TO DETAILS.
7. PROVIDE ALL CONTROLS, SENSORS, AND OPERATORS FOR NEW AIR HANDLING UNIT; REFER TO DETAILS.
8. PROVIDE CONTROLS FOR CABINET HEATER AND UNIT HEATER; REFER TO DETAILS.
9. PROVIDE INSTALLATION OF EXISTING i-WAVE AIR QUALITY PURIFIER IN AIR HANDLING UNIT FOLLOWING MANUFACTURER'S INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS.
10. PROVIDE FLOW METER IN CHILLED WATER SYSTEM.

LEGEND

SPACE SENSOR

(X-X) ZONE IDENTIFIER

B / M6.0 FIRST FLOOR - CONTROLS - NEW PLAN

Scale: 1/16" = 1'-0"

0 5' 10' 20' 30'

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HVAC CONTROLS PLANS

Drawn By:	TK, BBJ, MW
Scale:	AS NOTED
Job No.:	22-2038

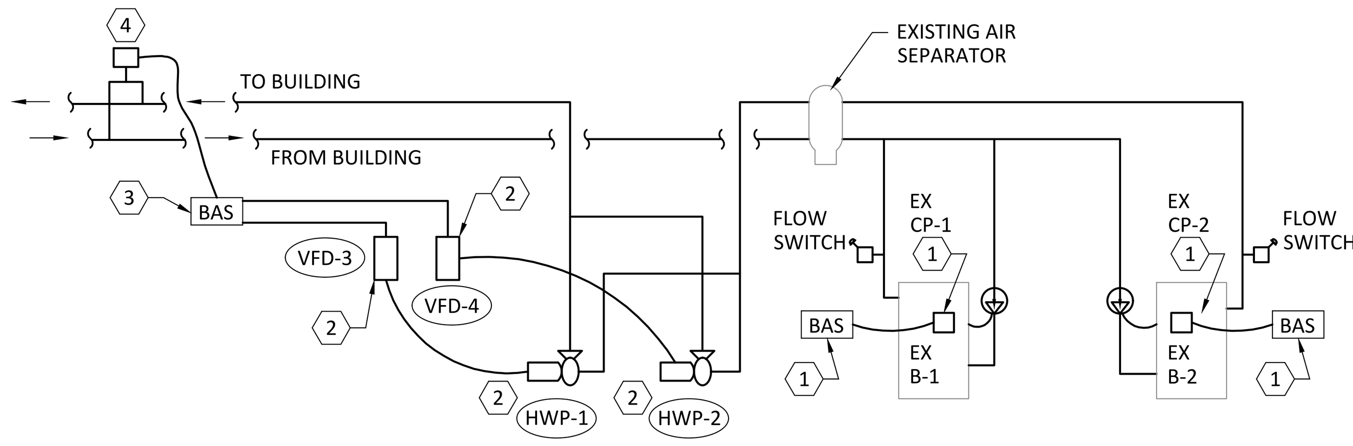
M6.0

File Location: C:\Users\conta\Dropbox\projects\Enhanse Engineering\20220623 Xenia - Green County Library\

Filename : M6.0_Mech Controls Plans.dwg Plot Date : Jan. 27, 2023 8:41pm

GENERAL NOTES

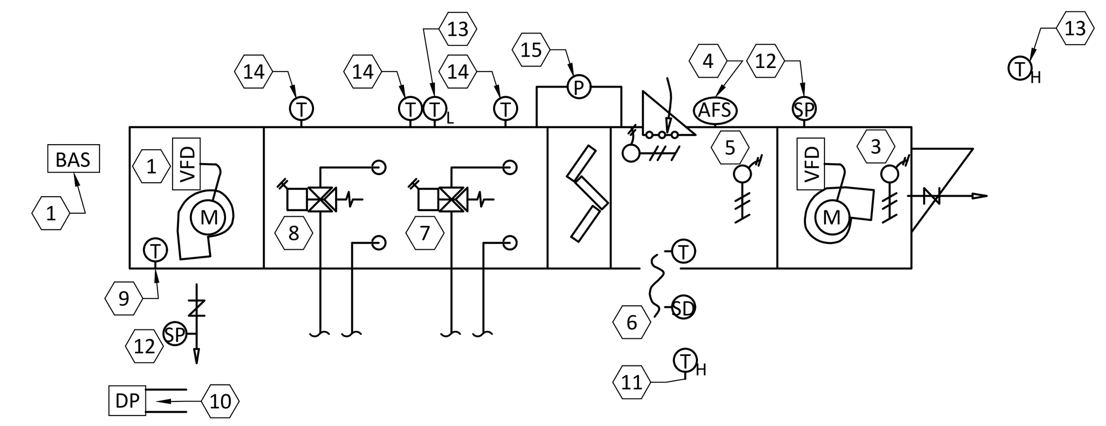
A. FOR ALL CONTROL ELEMENTS PROVIDE COMMUNICATION TO, AND CONTROL SEQUENCES FROM, THE BUILDING AUTOMATION SYSTEM. REFER TO OPERATING AND CONTROL SEQUENCES IN THE SPECIFICATIONS.
B. INSTALL CONTROL COMPONENTS FOLLOWING MANUFACTURERS INSTRUCTIONS AND RECOMMENDATIONS.



1 M6.1 DETAIL - HEATING HOT WATER CONTROLS SCHEMATIC DIAGRAM
NOT TO SCALE

1 - M6.1 NOTES

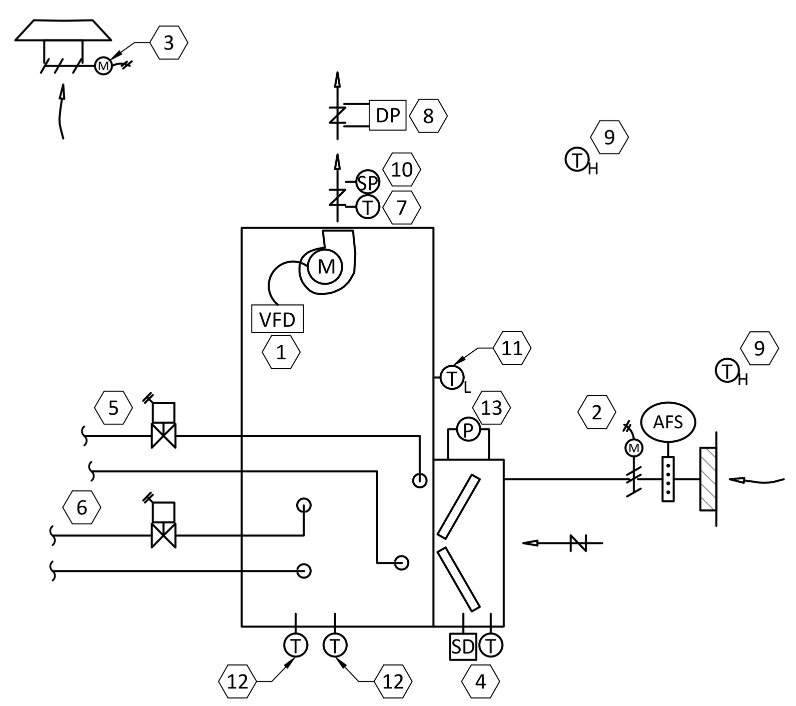
1. EXISTING BOILER INTEGRAL CONTROLS, CIRCULATOR OPERATION, FLOW SWITCH, SAFETY FEATURES, STAGING AND COMMUNICATION TO BUILDING AUTOMATION SYSTEM TO REMAIN. BUILDING LOOP DESIGN TO BE 140 F SUPPLY HEATING HOT WATER AND 120 F RETURN HEATING HOT WATER. REFER TO SEQUENCES IN THE SPECIFICATIONS.
2. NEW BUILDING HEATING HOT WATER LOOP PUMPS TO OPERATE FROM NEW VARIABLE FREQUENCY DRIVES.
3. NEW VARIABLE FREQUENCY DRIVES FOR PUMP CONTROL, PROVIDE COMMUNICATION AND SEQUENCES THROUGH BUILDING AUTOMATION SYSTEM. REFER TO SEQUENCES IN THE SPECIFICATIONS.
4. PRESSURE DIFFERENTIAL SENSOR NEAR FURTHEST END OF SYSTEM.



2 M6.1 DETAIL - AIR HANDLER CONTROLS SCHEMATIC DIAGRAM
NOT TO SCALE
AHU-1, AHU-2, AHU-3, AHU-5

2 - M6.1 NOTES

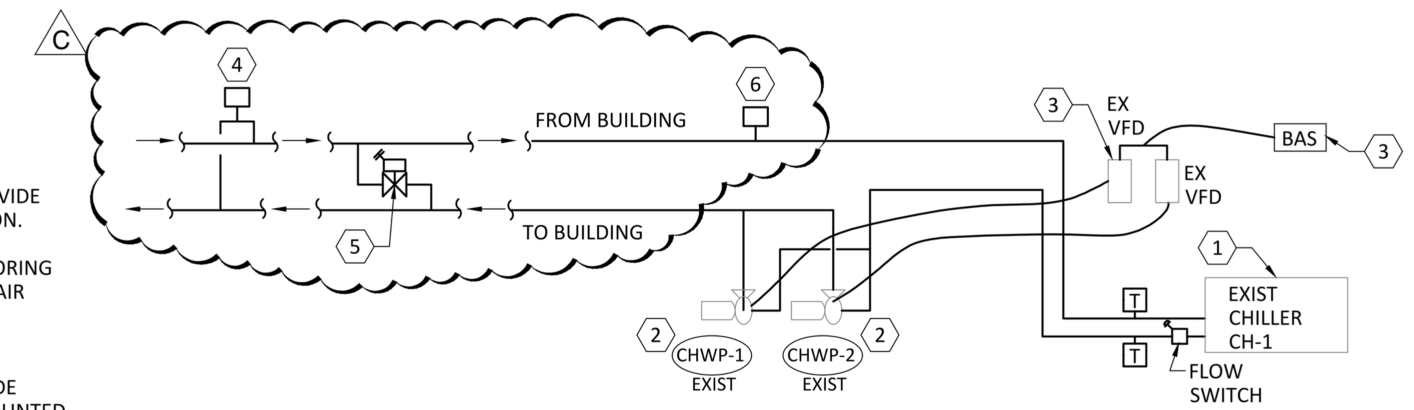
1. SUPPLY FAN AND VFD AT AIR HANDLING UNIT, PROVIDE FAN OPERATING CONTROL AND SPEED MODULATION,
2. EXHAUST FAN AND VFD AT AIR HANDLING UNIT, PROVIDE FAN OPERATING CONTROL AND SPEED MODULATION.
3. EXHAUST DAMPER AND MODULATING MOTOR OPERATOR AT AIR HANDLING UNIT.
4. OUTDOOR AIR INTAKE DAMPER AND MODULATING OPERATOR AT AIR HANDLING UNIT. PROVIDE AIRFLOW MONITORING STATION TO CONTINUOUSLY MEASURE OUTDOOR AIR FLOW.
5. RELIEF DAMPER AND MODULATING MOTOR OPERATOR AT AIR HANDLING UNIT MIXING SECTION.
6. SPACE RETURN AIR TO AIR HANDLING UNIT, PROVIDE RETURN AIR TEMPERATURE SENSOR AND DUCT MOUNTED SMOKE DETECTOR, COORDINATE WITH DIVISION 26.
7. PROVIDE TWO-WAY MODULATING CONTROL VALVES FOR HEATING COIL.
8. PROVIDE TWO-WAY MODULATING CONTROL VALVES FOR COOLING COIL.
9. PROVIDE BUILDING SUPPLY AIR TEMPERATURE SENSOR.
10. PROVIDE DUCT MOUNTED DIFFERENTIAL PRESSURE SENSOR IN DOWNSTREAM SUPPLY DUCTWORK LOCATED PER MANUFACTURER'S RECOMMENDATIONS.
11. PROVIDE TEMPERATURE AND HUMIDITY LEVEL SENSORS, REPRESENTATIVE OF INDOOR SPACE AND OUTDOOR CONDITIONS.
12. PROVIDE HIGH AND LOW STATIC PRESSURE SAFETY LIMIT SENSORS.
13. PROVIDE LOW TEMPERATURE SAFETY LIMIT SENSOR.
14. PROVIDE AIR TEMPERATURE SENSORS AT POINTS INDICATED IN THE AIR HANDLER.
15. PROVIDE DIFFERENTIAL PRESSURE SENSOR FOR FILTER MAINTENANCE AT THE AIR HANDLING UNIT.



3 M6.1 DETAIL - AIR HANDLER CONTROLS SCHEMATIC DIAGRAM
NOT TO SCALE
AHU-4

3 - M6.1 NOTES

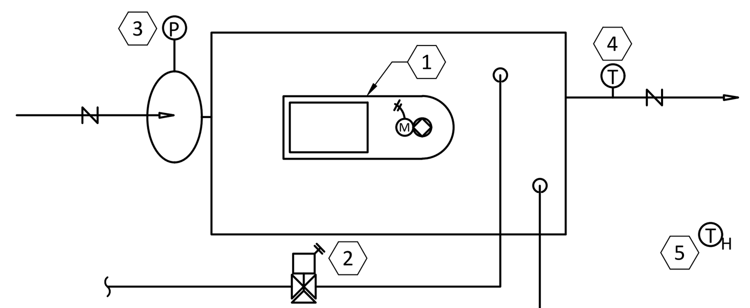
1. SUPPLY FAN AND VFD AT AIR HANDLING UNIT, PROVIDE FAN OPERATING CONTROL AND SPEED MODULATION.
2. OUTDOOR AIR INTAKE DAMPER AND MODULATING OPERATOR AT LOUVER. PROVIDE AIRFLOW MONITORING STATION TO CONTINUOUSLY MEASURE OUTDOOR AIR FLOW.
3. SPACE RELIEF AIR FAN AND MODULATING MOTOR OPERATOR AT ROOF.
4. SPACE RETURN AIR TO AIR HANDLING UNIT, PROVIDE RETURN AIR TEMPERATURE SENSOR AND DUCT MOUNTED SMOKE DETECTOR, COORDINATE WITH DIVISION 26.
5. PROVIDE TWO-WAY MODULATING CONTROL VALVES FOR COOLING COIL.
6. PROVIDE TWO-WAY MODULATING CONTROL VALVES FOR HEATING COIL.
7. PROVIDE BUILDING SUPPLY AIR TEMPERATURE SENSOR.
8. PROVIDE DUCT MOUNTED DIFFERENTIAL PRESSURE SENSOR IN DOWNSTREAM SUPPLY DUCTWORK LOCATED PER MANUFACTURER'S RECOMMENDATIONS.
9. PROVIDE TEMPERATURE AND HUMIDITY LEVEL SENSORS, REPRESENTATIVE OF INDOOR SPACE AND OUTDOOR CONDITIONS.
10. PROVIDE HIGH STATIC PRESSURE SAFETY LIMIT SENSOR.
11. PROVIDE LOW TEMPERATURE SAFETY LIMIT SENSOR.
12. PROVIDE AIR TEMPERATURE SENSORS AT POINTS INDICATED IN THE AIR HANDLER.
13. PROVIDE DIFFERENTIAL PRESSURE SENSOR FOR FILTER MAINTENANCE AT THE AIR HANDLING UNIT.



4 M6.1 DETAIL - CHILLED WATER CONTROLS SCHEMATIC DIAGRAM
NOT TO SCALE

4 - M6.1 NOTES

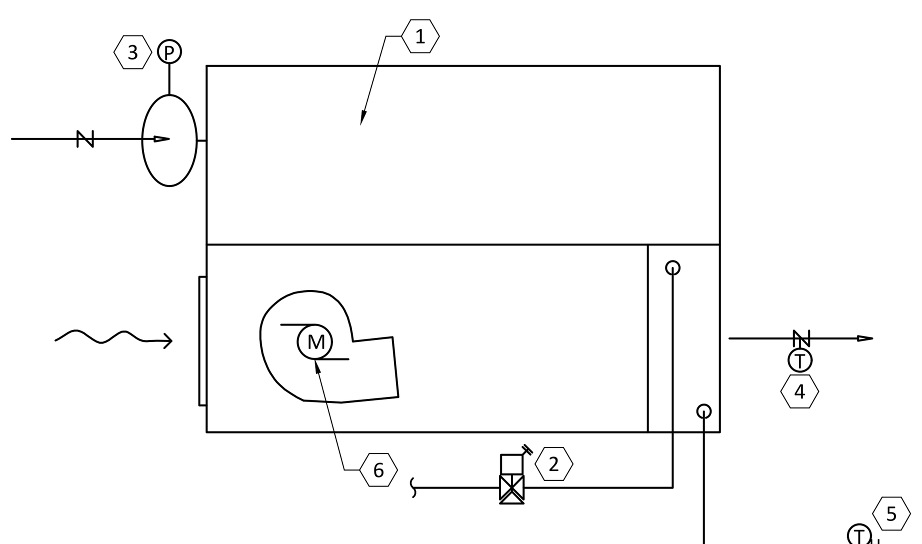
1. EXISTING CHILLER INTEGRAL CONTROLS, FLOW SWITCH, SAFETY FEATURES, TEMPERATURE AND STAGING, AND COMMUNICATION TO BUILDING AUTOMATION SYSTEM TO REMAIN. REFER TO SEQUENCES IN THE SPECIFICATIONS.
2. EXISTING BUILDING CHILLED WATER LOOP PUMPS TO OPERATE FROM EXISTING VARIABLE FREQUENCY DRIVES.
3. EXISTING VARIABLE FREQUENCY DRIVES PROVIDE COMMUNICATION AND SEQUENCES THROUGH BUILDING AUTOMATION SYSTEM. REFER TO SEQUENCES IN THE SPECIFICATIONS.
4. PRESSURE DIFFERENTIAL SENSOR NEAR FURTHEST END OF SYSTEM.
C
5. MINIMUM FLOW PRESSURE INDEPENDENT MODULATING CONTROL VALVE.
6. MINIMUM FLOW METER.



5 M6.1 HOT WATER REHEAT VARIABLE
DETAIL - AIR HANDLER CONTROLS SCHEMATIC DIAGRAM
NOT TO SCALE

5 - M6.1 NOTES

1. PROVIDE TERMINAL CONTROLLER FOR VARYING DAMPER POSITION AND UNIT CONTROL.
2. PROVIDE TWO-WAY MODULATING CONTROL VALVE FOR REHEAT COIL.
3. PROVIDE PRESSURE SENSOR TO MONITOR AIRFLOW AT TERMINAL FLOW RING.
4. PROVIDE DUCT MOUNTED SUPPLY AIR TEMPERATURE SENSOR.
5. PROVIDE TEMPERATURE AND HUMIDITY LEVEL SENSORS, REPRESENTATIVE OF INDOOR SPACE.



6 M6.1 HOT WATER REHEAT FAN-POWERED VARIABLE PRIMARY
DETAIL - AIR VOLUME TERMINAL - CONTROL SCHEMATIC DIAGRAM
NOT TO SCALE

6 - M6.1 NOTES

1. PROVIDE TERMINAL CONTROLLER FOR VARYING DAMPER POSITION AND UNIT CONTROL.
2. PROVIDE TWO-WAY MODULATING CONTROL VALVE FOR REHEAT COIL.
3. PROVIDE PRESSURE SENSOR TO MONITOR AIRFLOW AT TERMINAL FLOW RING.
4. PROVIDE DUCT MOUNTED SUPPLY AIR TEMPERATURE SENSOR.
5. PROVIDE TEMPERATURE AND HUMIDITY LEVEL SENSORS, REPRESENTATIVE OF INDOOR SPACE.
6. PROVIDE CONTROL FOR OPERATION OF TERMINAL INDUCTION FAN.

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HVAC CONTROLS DIAGRAMS

Drawn By:	TK, BBJ, MW
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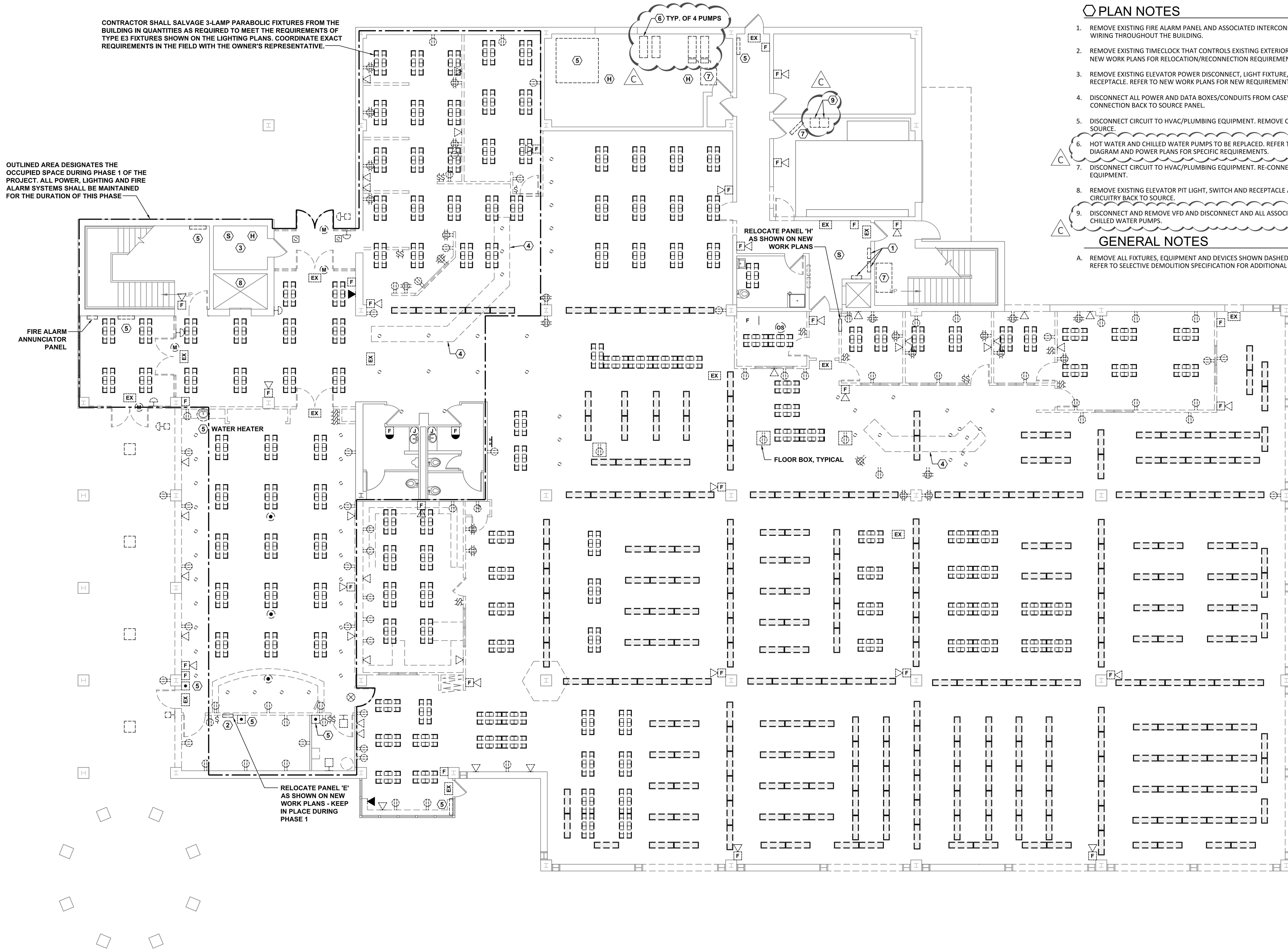
Job No.:	22-2038

M6.1

Filename : M6.1_Mech Controls Dia.dwg Plot Date : Jan. 27, 2023 8:50pm



FIRST FLOOR ELECTRICAL DEMOLITION PLAN

SCALE: 1/8" = 1'-0"

PLAN NOTES

1. REMOVE EXISTING FIRE ALARM PANEL AND ASSOCIATED INTERCONNECTED DEVICES AND WIRING THROUGHOUT THE BUILDING.
2. REMOVE EXISTING TIMECLOCK THAT CONTROLS EXISTING EXTERIOR LIGHTING, REFER TO NEW WORK PLANS FOR RELOCATION/RECONNECTION REQUIREMENTS.
3. REMOVE EXISTING ELEVATOR POWER DISCONNECT, LIGHT FIXTURE, SWITCH AND RECEPTACLE. REFER TO NEW WORK PLANS FOR NEW REQUIREMENTS.
4. DISCONNECT ALL POWER AND DATA BOXES/CONDUITS FROM CASEWORK. REMOVE ALL CONNECTION BACK TO SOURCE PANEL.
5. DISCONNECT CIRCUIT TO HVAC/PLUMBING EQUIPMENT. REMOVE CIRCUIT BACK TO SOURCE.
6. HOT WATER AND CHILLED WATER PUMPS TO BE REPLACED. REFER TO SINGLE LINE DIAGRAM AND POWER PLANS FOR SPECIFIC REQUIREMENTS. C
7. DISCONNECT CIRCUIT TO HVAC/PLUMBING EQUIPMENT. RE-CONNECT TO REPLACEMENT EQUIPMENT.
8. REMOVE EXISTING ELEVATOR PIT LIGHT, SWITCH AND RECEPTACLE AND ALL ASSOCIATED CIRCUITRY BACK TO SOURCE.
9. DISCONNECT AND REMOVE VFD AND DISCONNECT AND ALL ASSOCIATED FEEDERS FOR CHILLED WATER PUMPS. C

GENERAL NOTES

A. REMOVE ALL FIXTURES, EQUIPMENT AND DEVICES SHOWN DASHED ON THIS DRAWING. REFER TO SELECTIVE DEMOLITION SPECIFICATION FOR ADDITIONAL REQUIREMENTS.

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FIRST FLOOR ELECTRICAL DEMOLITION PLAN

Drawn By: JEP, CDG
Scale: AS NOTED
Job No.: 21-2113

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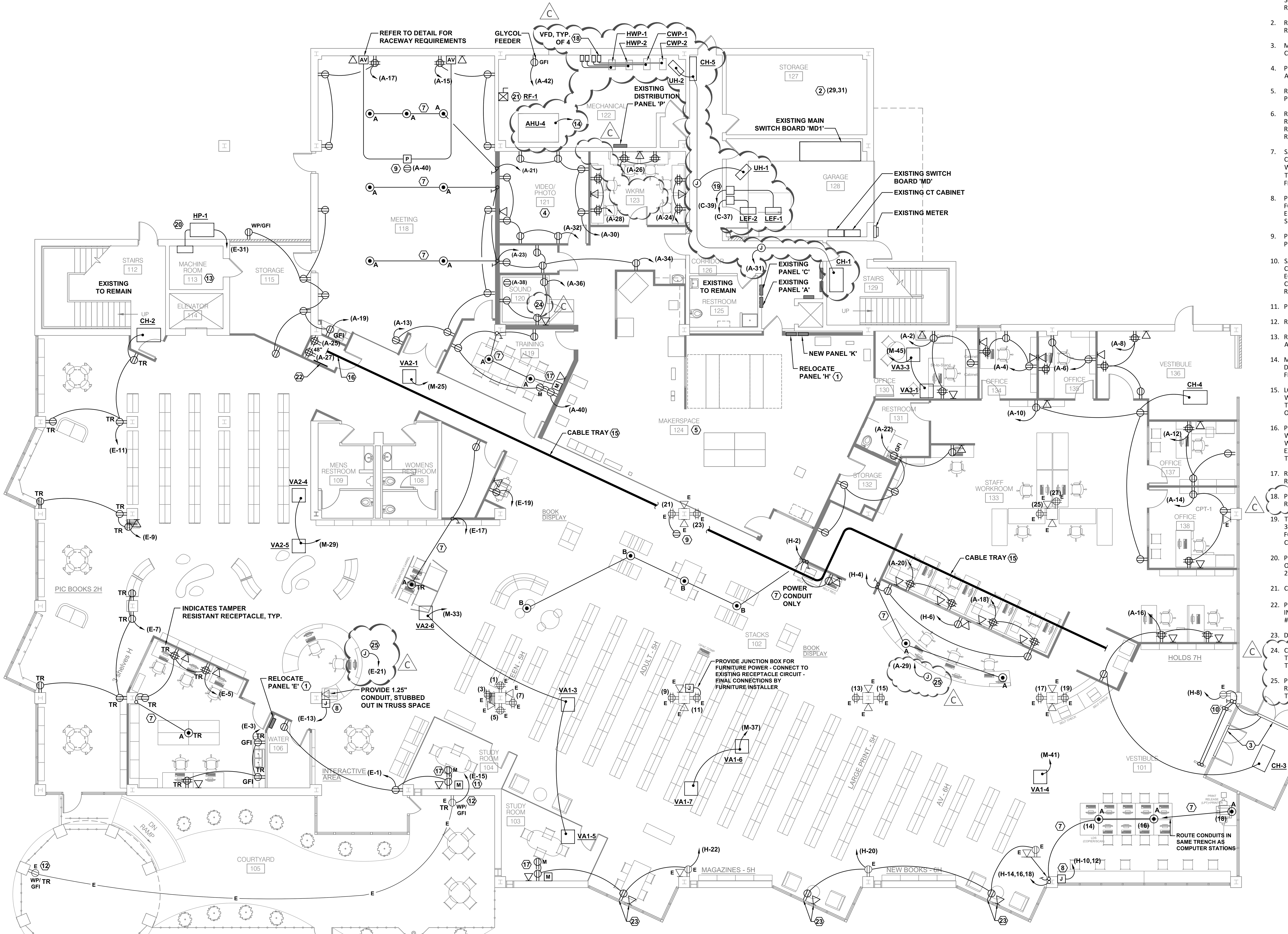

FIRST FLOOR POWER PLAN

SCALE: 1/8" = 1'-0"

GENERAL NOTES

A. REFER TO ARCHITECTURAL DRAWINGS FOR EXACT FLOOR BOX LOCATIONS. FIELD VERIFY DIMENSIONS IN FIELD WITH OWNER'S REPRESENTATIVE PRIOR TO COMMENCING SAW CUTTING ACTIVITIES.

PLAN NOTES

1. RELOCATE EXISTING BRANCH CIRCUIT PANEL TO NEW LOCATION AS SHOWN. EXTEND THE EXISTING FEEDER AS REQUIRED, MATCH EXISTING CONDUCTOR TYPE/SIZE AND CONDUIT SIZE. EXTEND ALL EXISTING BRANCH CIRCUITS AS SCHEDULED. PROVIDE NEW BRANCH CIRCUITS AS SCHEDULED. REFER TO PANEL SCHEDULE FOR CIRCUIT QUANTITIES.
2. RECONNECT TWO BRANCH CIRCUITS IN THIS ROOM TO RELOCATED PANEL H, REFER TO PANEL SCHEDULE.
3. MAKE CONNECTION TO POWER OPERATED DOORS CONTROLLER.
4. PROVIDE BOX EXTENSIONS FOR ALL DEVICES TO ACCOMMODATE INSULATED WALL PANELS IN THIS ROOM.
5. REFER TO DRAWING E2.3 ENLARGED PLAN FOR EQUIPMENT POWER REQUIREMENTS.
6. ROUTE CONDUITS DOWN COLUMN AND INTO CASEWORK. ROUTE CONDUITS WITHIN CASEWORK. COORDINATE ROUGH-IN REQUIREMENTS IN FIELD WITH OWNER'S REPRESENTATIVE.
7. SAW CUT EXISTING CONCRETE FLOOR SLAB FOR 1" POWER CONDUIT AND 1.25" NETWORK CONDUIT. ROUTE CONDUITS IN WALL/COLUMN ENCLOSURE. STUB NETWORK CONDUIT OUT IN TRUSS SPACE (OR ACCESSIBLE CEILING). RUN CONDUITS TO ALL FLOOR BOXES.
8. PROVIDE 1" POWER CONDUIT AND 1.25" NETWORK CONDUIT FOR WIREWAY CIRCUITS AND CABLING. RUN IN COLUMN ENCLOSURE AND STUB NETWORK CONDUIT OUT IN TRUSS SPACE.
9. PROVIDE CEILING MOUNTED DUPLEX RECEPTACLE FOR PROJECTOR AND/OR MONITOR.
10. SAW CUT EXISTING CONCRETE FLOOR SLAB FOR $\frac{3}{4}$" POWER CONDUIT AND 1" NETWORK CONDUIT FOR ANTI-THEFT EQUIPMENT. STUB CONDUITS UP AT THREE LOCATIONS. COORDINATE EXACT REQUIREMENTS WITH OWNER'S REPRESENTATIVE IN FIELD PRIOR TO COMMENCING WORK.
11. PROVIDE NEW CIRCUIT FOR EXISTING RECEPTACLES.
12. REPLACE EXISTING RECEPTACLE.
13. REFER TO DRAWING E2.3 FOR ELEVATOR POWER, LIGHTING AND CONTROL REQUIREMENTS.
14. MAKE FINAL CONNECTION TO FACTORY MOUNTED DISCONNECT SWITCH. REFER TO SINGLE LINE DIAGRAM FOR FEEDER REQUIREMENTS.
15. LOCATE CABLE TRAY ABOVE CEILING. COORDINATE LOCATION WITH DUCTWORK, SPRINKLER PIPING, ETC. WITH OTHER TRADES. PROVIDE OFFSETS AS REQUIRED TO MISS OBSTRUCTIONS.
16. PROVIDE VERTICAL SECTION OF TRAY, MOUNTED ON BACK WALL, TRANSITION INTO ANOTHER HORIZONTAL SECTION, THE WIDTH OF THE ROOM, ABOVE NETWORK RACKS. COORDINATE EXACT REQUIREMENTS WITH OWNER'S REPRESENTATIVE PRIOR TO INSTALLATION.
17. REFER TO "MONITOR ROUGH-IN DETAIL" FOR ADDITIONAL REQUIREMENTS.
18. PROVIDE NEW FEEDERS TO REPLACEMENT PUMPS AS SHOWN. REFER TO SINGLE LINE DIAGRAM FOR SPECIFIC REQUIREMENTS.
19. TWO VARIABLE FREQUENCY DRIVES, ONE PER FAN. PROVIDE A 30A, 2 HP RATED, 230-VOLT MOTOR RATED TOGGLE SWITCH FOR DISCONNECT AT EACH FAN (SQUARE D TYPE K). PROVIDE CIRCUITS AS SHOWN, (2 #10, 1 #10G, 3/4" C.)
20. PROVIDE FINAL CONNECTION TO INDOOR UNIT FROM OUTDOOR UNIT. PROVIDE NEMA 3R, 250-VOLT, 30-AMP, 2-POLE DISCONNECT MOUNTED ADJACENT TO UNIT.
21. COMBINATION STARTER FOR RF-1 LOCATED ON ROOF.
22. PROVIDE A $\frac{1}{4}$" x 2" x 20" COPPER GROUND BAR WITH INSULATED STAND-OFFS. CONNECT TO MAIN SERVICE WITH A #4 COPPER CONDUCTOR.
23. DELETE DEVICES AND CIRCUITING UNDER ALTERNATE 2B.
24. COORDINATE EXACT MOUNTING HEIGHTS OF ALL DEVICES FOR THE SOUND BOOTH WITH OWNER'S REPRESENTATIVE PRIOR TO ROUGHING IN WORK.
25. PROVIDE CIRCUIT FOR FUTURE SIGNAGE. COORDINATE ROUGH-IN LOCATION WITH OWNER'S REPRESENTATIVE PRIOR TO ROUGHING IN.

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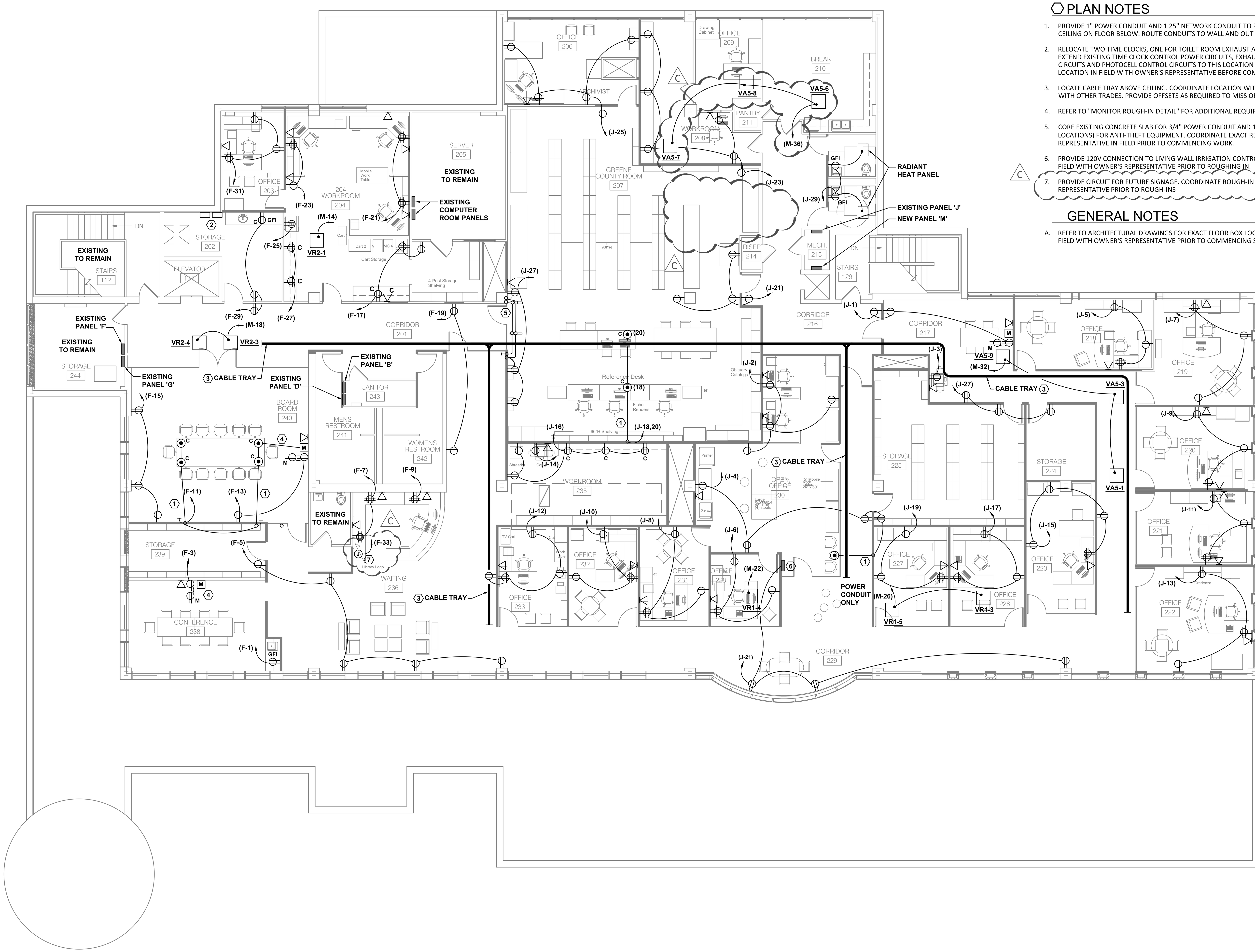
FIRST FLOOR POWER PLAN

Drawn By:	JEP, CDG
Scale:	AS NOTED
Job No.:	21-2113

E2.1



SECOND FLOOR POWER PLAN

SCALE: 1/8" = 1'-0"

PLAN NOTES

1. PROVIDE 1" POWER CONDUIT AND 1.25" NETWORK CONDUIT TO POKE-THRU FLOOR BOXES. RUN ABOVE CEILING ON FLOOR BELOW. ROUTE CONDUITS TO WALL AND OUT TO ABOVE CEILING THIS FLOOR.
2. RELOCATE TWO TIME CLOCKS, ONE FOR TOILET ROOM EXHAUST AND ONE FOR BUILDING SIGNAGE. EXTEND EXISTING TIME CLOCK CONTROL POWER CIRCUITS, EXHAUST FAN CIRCUIT, THREE BUILDING SIGN CIRCUITS AND PHOTOCELL CONTROL CIRCUITS TO THIS LOCATION AS REQUIRED. COORDINATE EXACT LOCATION IN FIELD WITH OWNER'S REPRESENTATIVE BEFORE COMMENCING WITH THE WORK.
3. LOCATE CABLE TRAY ABOVE CEILING. COORDINATE LOCATION WITH DUCTWORK, SPRINKLER PIPING, ETC. WITH OTHER TRADES. PROVIDE OFFSETS AS REQUIRED TO MISS OBSTRUCTIONS.
4. REFER TO "MONITOR ROUGH-IN DETAIL" FOR ADDITIONAL REQUIREMENTS.
5. CORE EXISTING CONCRETE SLAB FOR 3/4" POWER CONDUIT AND 1.25" NETWORK CONDUIT (AT THREE LOCATIONS) FOR ANTI-THEFT EQUIPMENT. COORDINATE EXACT REQUIREMENTS WITH OWNER'S REPRESENTATIVE IN FIELD PRIOR TO COMMENCING WORK.
6. PROVIDE 120V CONNECTION TO LIVING WALL IRRIGATION CONTROLLER. COORDINATE EXACT LOCATION IN FIELD WITH OWNER'S REPRESENTATIVE PRIOR TO ROUGHING IN.
7. PROVIDE CIRCUIT FOR FUTURE SIGNAGE. COORDINATE ROUGH-IN LOCATION WITH OWNER'S REPRESENTATIVE PRIOR TO ROUGH-INS

C

GENERAL NOTES

A. REFER TO ARCHITECTURAL DRAWINGS FOR EXACT FLOOR BOX LOCATIONS. FIELD VERIFY DIMENSIONS IN FIELD WITH OWNER'S REPRESENTATIVE PRIOR TO COMMENCING SAW CUTTING ACTIVITIES.

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SECOND FLOOR POWER PLAN

Drawn By:	JEP, CDG
Scale:	AS NOTED
Job No.:	21-2113

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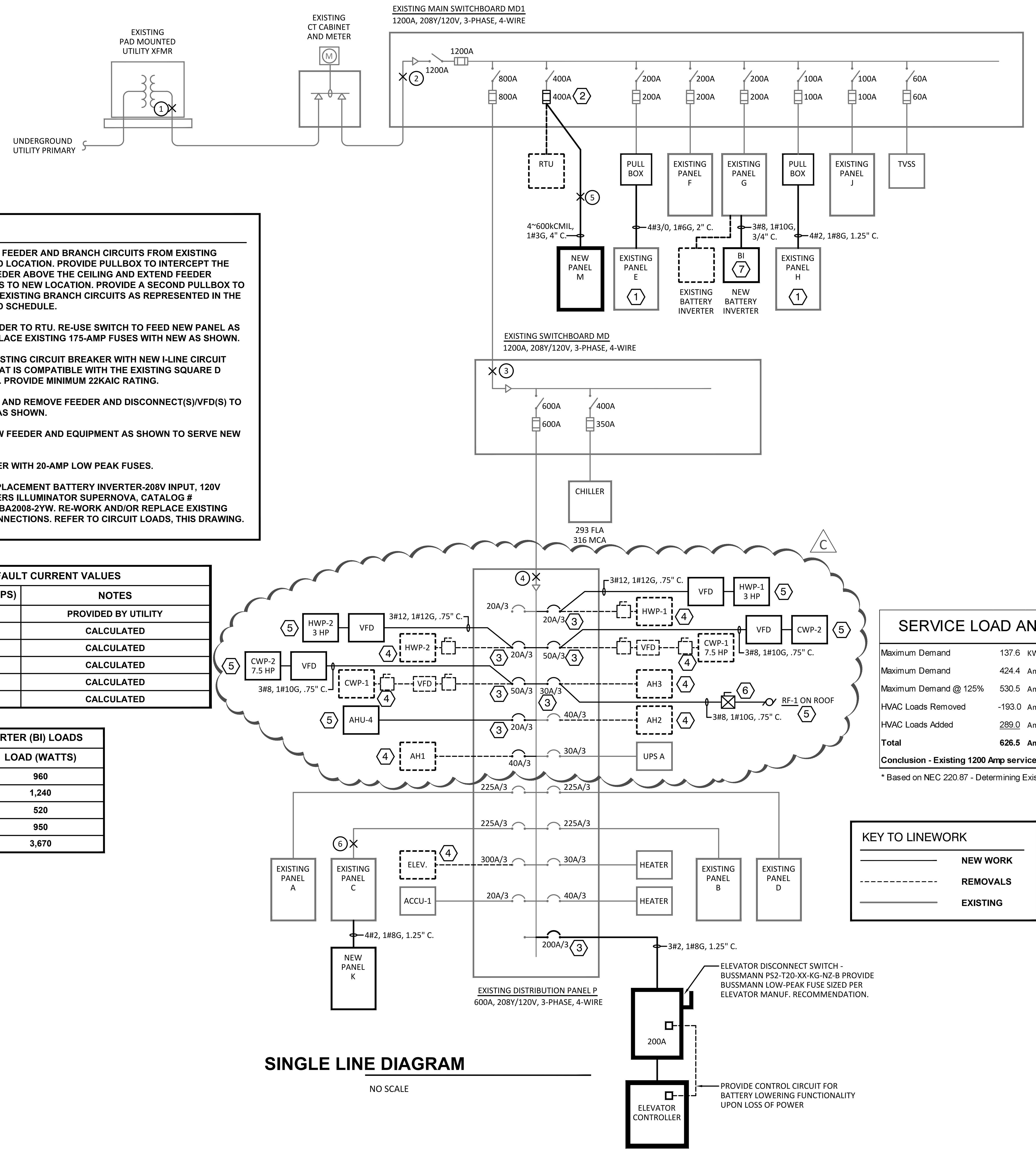

SINGLE LINE DIAGRAM

NO SCALE

NOTES:

1. DISCONNECT FEEDER AND BRANCH CIRCUITS FROM EXISTING PANELBOARD LOCATION. PROVIDE PULLBOX TO INTERCEPT THE EXISTING FEEDER ABOVE THE CEILING AND EXTEND FEEDER CONDUCTORS TO NEW LOCATION. PROVIDE A SECOND PULLBOX TO EXTEND THE EXISTING BRANCH CIRCUITS AS REPRESENTED IN THE PANELBOARD SCHEDULE.
2. REMOVE FEEDER TO RTU. RE-USE SWITCH TO FEED NEW PANEL AS SHOWN. REPLACE EXISTING 175-AMP FUSES WITH NEW AS SHOWN.
3. REPLACE EXISTING CIRCUIT BREAKER WITH NEW I-LINE CIRCUIT BREAKER THAT IS COMPATIBLE WITH THE EXISTING SQUARE D I-LINE PANEL. PROVIDE MINIMUM 22KAIC RATING.
4. DISCONNECT AND REMOVE FEEDER AND DISCONNECT(S)/VFD(S) TO EQUIPMENT AS SHOWN.
5. PROVIDE NEW FEEDER AND EQUIPMENT AS SHOWN TO SERVE NEW EQUIPMENT.
6. FUSE STARTER WITH 20-AMP LOW PEAK FUSES.
7. PROVIDE REPLACEMENT BATTERY INVERTER-208V INPUT, 120V OUTPUT. MYERS ILLUMINATOR SUPERNOVA, CATALOG # 3-E-5-S-R120-BA2008-2YW. RE-WORK AND/OR REPLACE EXISTING CONDUIT CONNECTIONS. REFER TO CIRCUIT LOADS, THIS DRAWING.

FAULT CURRENT VALUES

	VALUE (AMPS)	NOTES
1	33,997	PROVIDED BY UTILITY
2	27,894	CALCULATED
3	25,250	CALCULATED
4	18,745	CALCULATED
5	19,860	CALCULATED
6	8,301	CALCULATED

BATTERY INVERTER (BI) LOADS

CIRCUIT	LOAD (WATTS)
BI-1	960
BI-2	1,240
BI-3	520
BI-4	950
TOTAL	3,670

GENERAL PROJECT NOTES

A. ALL WORK SHALL CONFORM TO THE LATEST ADOPTED EDITIONS OF THE NATIONAL ELECTRICAL CODE (NEC), OHIO BUILDING CODE (OBC) AND ANY APPLICABLE LOCAL CODE.
B. ALL EQUIPMENT SHALL BE NEW AND CONFORM TO NEMA STANDARDS AND BE UL LISTED AND LABELED.
C. ALL EQUIPMENT SHALL BE INSTALLED IN COMPLIANCE WITH MANUFACTURER'S WRITTEN INSTRUCTIONS. INSTALLATION SHALL ENSURE THAT PROPER CLEARANCE IS MAINTAINED FOR VENTILLATION AND REQUIRED SERVICE ACCESS.
D. ALL FEEDERS AND BRANCH CIRCUITS SHALL BE RUN IN EMT, UNLESS NOTED OTHERWISE, OR OTHERWISE NOT PERMITTED BY CODE.
E. ALL CONDUCTORS SHALL BE COPPER, MINIMUM #12 AWG, UNLESS NOTED OTHERWISE.
F. CONNECT EXIT SIGNS AND EMERGENCY LIGHTS TO LOCAL EMERGENCY LIGHTING CIRCUITS.
G. PROVIDE GFCI PROTECTION FOR RECEPTACLES WHERE REQUIRED BY CODE.
H. PROVIDE WIRE SIZE PER NEC TO MATCH CIRCUIT BREAKER SIZE.
I. ALL FEEDERS AND BRANCH CIRCUITS SHALL BE CONCEALED WHERE POSSIBLE.
J. PENETRATIONS OF RATED ASSEMBLIES (FIRE OR SMOKE) SHALL BE PROPERLY SLEEVED AND SEALED TO MAINTAIN THE RATING OF THE ASSEMBLY.
K. ALL BRANCH CIRCUITS SHALL UTILIZE A DEDICATED NEUTRAL FOR EACH INDIVIDUAL BRANCH CIRCUIT.
L. ALL BRANCH CIRUITS SHALL CONTAIN AN EQUIPMENT GROUNDING CONDUCTOR. GROUNDING SOLELY THROUGH THE RACEWAY SYSTEM IS STRICTLY PROHIBITED.
M. REFER TO ARCHITECTURAL PLANS FOR INFORMATION REGARDING OUTLET LOCATIONS AND MOUNTING HEIGHTS.
N. PROVIDE LINE VOLTAGE AND LOW VOLTAGE WIRING FOR LIGHTING CIRCUITS AS REQUIRED FOR CONTROL FUNCTIONALITY.
O. ALL EXISTING BRANCH CIRCUITS LEFT TO REMAIN SHALL BE TRACED BACK TO ITS SOURCE. PROVIDE CIRCUIT IDENTIFICATION FOR ALL EXISTING FIXTURES, EQUIPMENT AND WIRING DEVICES LEFT TO REMAIN. PROVIDE CIRCUIT DIRECTORIES FOR ALL PANELS, EXISTING AND NEW. PROVIDE ROOM NUMBERS AND INDICATE WHAT EACH CIRCUIT SERVES.
P. THE EXISTING STRUCTURAL STEEL IN THE BUILDING IS PROTECTED WITH SPRAY APPLIED FIREPROOFING. CARE SHALL BE TAKEN WHERE ATTACHMENT TO STRUCTURAL MEMBERS IS REQUIRED TO ONLY REMOVE WHAT IS NECESSARY FOR THE ATTACHMENT HARDWARE. THE CONTRACTOR SHALL SPOT PATCH ANY AREAS WHERE EXCESS MATERIAL WAS REMOVED.
Q. ALL EXPOSED RACEWAYS SHALL BE PAINTED PER DIVISION 9 SPECIFICATION SECTION. THIS INCLUDES CONDUITS IN THE CEILING CAVATIES WITHOUT ACOUSTICAL TILE LAY-IN CEILINGS OR DRYWALL CEILINGS. RACEWAYS SHALL BE PREPPED (DE-GREASED AND CLEANED) SUFFICIENTLY TO RECEIVE PAINT.

SERVICE LOAD ANALYSIS

Maximum Demand	137.6	KW
Maximum Demand	424.4	Amps
Maximum Demand @ 125%	530.5	Amps*
HVAC Loads Removed	-193.0	Amps
HVAC Loads Added	289.0	Amps
Total	**626.5**	**Amps**

Conclusion - Existing 1200 Amp service is adequate

* Based on NEC 220.87 - Determining Existing Loads

KEY TO LINEWORK

NEW WORK
REMOVALS
EXISTING

PANEL: M (New) 400 Amp, Main Lugs 208Y/120V, 3-Phase, 4-Wire + Ground, 22k AIC Flush Mounted NEMA 1

BREAKER A	BREAKER P	LTS	REC	MTR	EQP	DESCRIPTION	CKT #	PHASE LOAD A	PHASE LOAD B	PHASE LOAD C	CKT #	DESCRIPTION	LTS	REC	MTR	EQP	BREAKER A	BREAKER P
80	3				5.50	AHU-1 (3#4, 1#8G, 1"C)	1	13.10			2	RTU-1 (3#4, 1#8G, 1"C)				7.60	80	3
/	/				5.50	-	3		13.10		4	-				7.60	/	/
/	/				5.50	-	5			13.10	6	-				7.60	/	/
60	3				4.60	AHU-2 (3#6, 1#10G, 3/4"C)	7	12.20			8	RTU-2 (3#4, 1#8G, 1"C)				7.60	80	3
/	/				4.60	-	9		12.20		10	-				7.60	/	/
/	/				4.60	-	11			12.20	12	-				7.60	/	/
45	3				3.10	AHU-3 (3#8, 1#10G, 3/4"C)	13	3.66			14	VR2-1				0.56	20	2
/	/				3.10	-	15		3.66		16	-				0.56	/	/
/	/				3.10	-	17			4.22	18	VR2-3, VR2-4				1.12	20	2
60	3				3.90	AHU-5 (3#6, 1#10G, 3/4"C)	19	5.02			20	-				1.12	/	/
/	/				3.90	-	21		4.70		22	VR1-4				0.80	20	2
/	/				3.90	-	23			4.70	24	-				0.80	/	/
20	2				0.80	VA2-1	25	1.60			26	VR1-3, VR1-5				0.80	20	2
/	/				0.80	-	27		1.60		28	-				0.80	/	/
20	2				1.12	VA2-4, VA2-5	29			1.42	30	EF-1				0.30	20	1
/	/				1.12	-	31	2.37			32	VA5-1, VA5-3, VA5-9				1.25	20	2
20	2				1.25	VA2-6, VA1-3, VA1-5	33		2.50		34	-				1.25	/	/
/	/				1.25	-	35			2.50	36	VA5-6, VA5-7, VA5-8				1.25	20	2
20	2				1.12	VA1-6, VA1-7	37	2.37			38	-				1.25	/	/
/	/				1.12		39		1.12		40							
20	2				0.80	VA1-4	41			0.80	42							
/	/				0.80	-	43	0.80			44							
20	2				0.80	VA3-1, VA3-3	45		0.80		46							
/	/				0.80	-	47			0.80	48							
							49	0.00			50							
							51		0.00		52							
							53			0.00	54							
								41.12	39.68	39.74								

REMARKS:

TOTAL LOADS:

0.00 Lights
0.00 Receptacle
0.00 Motor
120.54 Equipment

120.54 kVA

335.0 Amps

FLOOR BOX SCHEDULE

TYPE	LEGRAND SERIES	BOX TYPE	HOLE CORE SIZE	GANGS / SERVICE	BOX DEPTH	UL RATING	UTILITIES	ACTIVATION COVER	COVER COLOR	POWER DEVICE / PLATE	LOW VOLTAGE DEVICE PLATE	POWER CONDUIT	LOW VOLTAGE CONDUIT	NOTES
A	RFBA*C** OG	CAST IN PLACE	N/A	2-GANG	3.75 INCH	N/A	POWER AND LOW VOLTAGE	6CTC2BK	BLACK	DUPLEX RECEPTACLE	TBD - Note 1	1 INCH	1.25 INCH	PROVIDE CLOSURE PLATES AS REQUIRED TO MAINTAIN 2-GANG ACCESSIBILITY
B	RATCHET PRO 881	CAST IN PLACE	N/A	1-GANG	4.5" to 6" MAX.	N/A	POWER ONLY	899CTCBK	BLACK	QUAD RECEPTACLE	N/A	1 INCH	N/A	
C	EVOLUTION 6" POKE THRU	POKE-THRU	6 INCH	MULTI-SERVICE	N/A	2-HOUR	POWER AND LOW VOLTAGE	6CTC2BK	BLACK	QUAD RECEPTACLE	TBD - Note 1	3/4 INCH	1.25 INCH	
D	RC9	POKE-THRU	3-1/16 INCH	POWER ONLY	N/A	2-HOUR	POWER ONLY	RC9SHTCBK	BLACK	QUAD RECEPTACLE	N/A	3/41 INCH	N/A	

Note 1 - Coordinate requirements with Owner's Representative prior to ordering.

General Note - Provide all necessary components and accessories as required for a complete and operational system.

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COMPLETE RENOVATION/MECHANICAL UPGRADES:
Greene County Public Library
XENIA COMMUNITY LIBRARY
76 EAST MARKET STREET
XENIA, OH 45385

REVISIONS / SUBMISSIONS

NO.	DESCRIPTION	DATE
	BID ISSUE	01/04/23
C	ADDENDUM C	01/27/23

PRELIMINARY BID NOT FOR CONSTRUCTION

ELECTRICAL DETAILS & SINGLE LINE DIAGRAM

Drawn By:	JEP, CDG
Scale:	AS NOTED
Job No.:	21-2113

E4.1

TYPE	DESCRIPTION	DIMENSION	MOUNTING	CONSTRUCTION / FINISH	OPTICS / DIFFUSER	LUMEN PACKAGE	COLOR TEMPERATURE	DRIVER	VOLTAGE	WATTS	MANUFACTURER / MODEL #	NOTES
A1	LED LAY-IN WITH LUMINOUS CENTER	2' x 4'	GRID	CODE GAUGE STEEL - PAINTED WHITE	FROSTED ACRYLIC LENS	3000LM	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	30	MARK WHSPR LCTR SWC SERIES	
A2	LED LAY-IN WITH LUMINOUS CENTER	2' x 2'	GRID	CODE GAUGE STEEL - PAINTED WHITE	FROSTED ACRYLIC LENS	3300LM	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	30	MARK WHSPR LCTR SWC SERIES	
A3	LED LAY-IN WITH LUMINOUS CENTER	1' x 4'	GRID	CODE GAUGE STEEL - PAINTED WHITE	FROSTED ACRYLIC LENS	3300LM	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	26	MARK WHSPR LCTR SWC SERIES	
A4	LED LAY-IN WITH LUMINOUS CENTER	1' x 4'	GRID	CODE GAUGE STEEL - PAINTED WHITE	FROSTED ACRYLIC LENS	2000LM	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	19	MARK WHSPR LCTR SWC SERIES	
C1	LED PERMITER COVE	4" WIDE X LENGTH SHOWN ON DRAWING	WALL	CODE GAUGE STEEL - PAINTED WHITE	FROSTED ACRYLIC LENS	375LM / FOOT	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	15 / 4-FT	FOCAL POINT FSM4PR-ALH-FL2 SERIES	PROVIDE CONTINUOUS ROWS WITH LENGTHS AS SHOWN ON DRAWINGS
D1	4" ROUND RECESSED LED DOWNLIGHT	4" ROUND X 7" DEEP	GRID	CODE GAUGE STEEL HOUSING	SELF FLANGE SEMI-SPECULAR CLEAR REFLECTOR	1500	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	18	LITHONIA LDN4 SERIES	
D2	6" ROUND RECESSED LED DOWNLIGHT WITH DROP LUMINOUS RING	6" ROUND X 7" DEEP	GRID	CODE GAUGE STEEL HOUSING	SELF FLANGE SEMI-SPECULAR CLEAR REFLECTOR WITH LUMINOUS RING	2000	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	20	GOTHAM EVO6DLD SERIES	
D3	6" ROUND RECESSED DOWNLIGHT WITH DROP LUMINOUS DISK	6" ROUND X 7" DEEP	GRID	CODE GAUGE STEEL HOUSING	SELF FLANGE SEMI-SPECULAR CLEAR REFLECTOR WITH LUMINOUS DISK	2000	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	20	GOTHAM EVO6DLR SERIES	
E3	EXISTING LED LAY-IN	2' X 4'	GRID	CONTRACTOR SHALL GENTLY REMOVE/STORE EXISTING 3-LAMP PARABOLIC LAY-IN FIXTURE DURING THE DEMOLITION PHASE AND RE-INSTALL AS SHOWN ON THE LIGHTING PLANS - FIXTURES SHALL BE THOROUGHLY CLEANED								REMOVE/SALVAGE QUANTITIES AS REQUIRED BY LIGHTING PLANS
L1	PENDANT MOUNTED LED BOOK STACK FIXTURE	2-3/4" WIDE X 3" DEEP	AIRCRAFT CABLE	EXTRUDED ALUMINUM HOUSING - POWER COATED FINISH	POLYCARBONATE CROSS BAFFLE, BI-ASYMMETRIC OPTIC	680LM / FOOT	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	27 / 4-FT	ELLIPTIPAR S531-COLOR SERIES	PROVIDE CONTINUOUS ROWS WITH LENGTHS AS SHOWN ON DRAWINGS
L2	THIN PROFILE RECESSED LINEAR LED	2.6" WIDE X 4" DEEP	CEILING RECESSED AND PENDANT	EXTRUDED ALUMINUM HOUSING - POWER COATED FINISH	FROSTED ACRYLIC LENS	500LM / FOOT	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	18 / 4-FT	FOCAL POINT FSM2L-FL SERIES	PROVIDE CONTINUOUS ROWS WITH LENGTHS AS SHOWN ON DRAWINGS
L3	PENDANT MOUNTED LINEAR LED	2.6" WIDE X 4.5" DEEP	AIRCRAFT CABLE	EXTRUDED ALUMINUM HOUSING - POWER COATED FINISH	FROSTED ACRYLIC LENS	500LM / FOOT	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	19 / 4-FT	FOCAL POINT FSM2LS-FL-COLOR SERIES	PROVIDE FIXTURE LENGTHS AS SHOWN ON PLANS - FIXTURES ARE PRIMARILY RECESSED IN A GRID CEILING, HOWEVER, SOME OF THE FIXTURES GO RUN PAST THE GRID CEILING INTO AREAS OF NO CEILING - FIXUTRES SHALL BE INSTALLED IN CONTINUOUS ROWS AND SHALL BE SUPPORTED BY AIRCRAFT CABLES FROM THE STRUCTURE
L4	PENDANT MOUNTED LINEAR LED	2.6" WIDE X 4.5" DEEP	AIRCRAFT CABLE	EXTRUDED ALUMINUM HOUSING - POWER COATED FINISH	FROSTED ACRYLIC LENS	625LM / FOOT	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	24 / 4-FT	FOCAL POINT FSM2LS-FL-COLOR SERIES	PROVIDE FIXTURE LENGTHS AS SHOWN ON PLANS
L5	PENDANT MOUNTED LINEAR LED	2.6" WIDE X 4.5" DEEP	AIRCRAFT CABLE	EXTRUDED ALUMINUM HOUSING - POWER COATED FINISH	FROSTED ACRYLIC LENS	375LM / FOOT	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	14 / 4-FT	FOCAL POINT FSM2LS-FL-COLOR SERIES	PROVIDE FIXTURE LENGTHS AS SHOWN ON PLANS
M1	LED LINEAR SUSPENDED PENDANT	12" WIDE X 4'	AIRCRAFT CABLE	COLD-ROLLED STEEL HOUSING - POWER COATED FINISH	HIGH PERFORMANCE LENS - DIRECT/INDIRECT	800LM / FOOT	4000K	0-10 VOLT - 1% DIMMING	MULTI-VOLT	24 / 4-FT	MARK PLANAR PLN8 30/70 SERIES	PROVIDE CONTINUOUS ROWS WITH LENGTHS AS SHOWN ON DRAWINGS
P1	7" DIAMETER LED PENDANT	7" ROUND X 11"	CORD	SPUN ALUMINUM HOUSING	FROSTED ACRYLIC LENS	800	4000K	0-10 VOLT - 1% DIMMING	120	60	NORDIC 11350WNBP	
P2	20" DIAMETER LED PENDANT	20" ROUND X 3.75"	AIRCRAFT CABLE	ROLLED EXTRUDED ALUMINUM HOUSING / POWER COAT FINISH	HIGH PERFORMANCE THERMOFORMED ACRYLIC DIFFUSER	2655	4000K	0-10 VOLT - 5% DIMMING	MULTI-VOLT	38	A-LIGHT ATL3-20-LH SERIES	
P3	6" DIAMETER LED PENDANT CYLINDER DOWNLIGHT	8" ROUND X 11" TALL	CORD	SPUN ALUMINUM HOUSING	SELF FLANGED ANODIZED SEMI-SPECULAR REFLECTOR	2000	4000K	0-10 VOLT - 5% DIMMING	MULTI-VOLT	10	LITHONIA LDN4CYL-COLOR SERIES	
P4	6-FOOT DIAMETER LED ACOUSTIC RING PENDANT	6-FOOT ROUND X 12"	AIRCRAFT CABLE	ACRYLIC FRAME CLAD WITH SOLA FELT	FROSTED WHITE OPAL BOTTOM DIFFUSER	5000	4000K	0-10 VOLT - 5% DIMMING	MULTI-VOLT	116	ACOUSTIC RING 6-12-COLOR SERIES	
P5-24	24" DIAMETER LED PENDANT	24" ROUND X 1.75"	AIRCRAFT CABLE	ROLLED EXTRUDED ALUMINUM HOUSING / POWER COAT FINISH	SILICONE DIFFUSER	1176	4000K	0-10 VOLT - 5% DIMMING	MULTI-VOLT	21	OCL RV1-P1DB-24-MW-COLOR-LED1 SERIES	
P5-36	SAME AS P5-24 EXCEPT 36" DIAMETER					1792	4000K	0-10 VOLT - 5% DIMMING	MULTI-VOLT	32	SAME AS P5-24 EXCEPT 36" DIAMETER	
P5-48	SAME AS P5-24 EXCEPT 48" DIAMETER					2352	4000K	0-10 VOLT - 5% DIMMING	MULTI-VOLT	42	SAME AS P5-24 EXCEPT 48" DIAMETER	
P6-12	6" SPHERE LED PENDANT	6" SPHERE	CORD	GLOBE WITH SPUN ALUMINUM CAP	OPAL WHITE GLASS GLOBE	1540	4000K	0-10 VOLT - 5% DIMMING	MULTI-VOLT	21	OCL EU1-P1CB-W-12-COLOR-LED2 SERIES	
P6-16	SAME AS P6-12 EXCEPT 16" SPHERE					1540	4000K	0-10 VOLT - 5% DIMMING	MULTI-VOLT	21	SAME AS P6-12 EXCEPT 16" SPHERE	
P7	12" DIAMTER LED PENDANT	12" ROUND X 16"	PENDANT STEM	ACRYLIC REFRACTOR WITH EXTRUDED ALUMINUM HOUSING CAP / POWER COAT FINISH	FROSTED ACRYLIC REFRACTOR	3304	4000K	0-10 VOLT - 5% DIMMING	MULTI-VOLT	24	PATHWAY P80-PV-COLOR-COLOR-PAM SERIES	
P8	20" DIAMETER LED PENDANT	20" ROUND X 9"	PENDANT STEM	SATIN NICKEL	WHITE LINEN FABRIC SHADE	3200	4000K	0-10 VOLT - 5% DIMMING	MULTI-VOLT	35	AFX DYP2432LAJUDSN	
P9	36" DIAMETER LED PENDANT	36" ROUND X 2" DEEP	AIRCRAFT CABLE	ROLLED EXTRUDED ALUMINUM HOUSING / POWER COAT FINISH	POLYCARBONATE SATINE LENS	6000	4000K	0-10 VOLT - 5% DIMMING	MULTI-VOLT	74	LUMENWERX RIMRP-36-ULO-COLOR-WAC-SC-COLOR	
S1	4-FOOT LED STRIP	2.6" WIDE X 2.2" DEEP	CHAIN HUNG	CODE COMPLIANT STEEL - PAINTED WHITE	DIFFUSE ACRYLIC LENS	ADJUSTABLE LUMEN OUTPUT	4000K	STANDARD LED DRIVER	MULTI-VOLT	35	LITHONIA CSS SERIES	
T1	TRACK	N/A	CEILING	DIE-CAST ALUMINUM HOUSING	SEALED LAMP	2341	4000K	STANDARD LED DRIVER NON-DIM	120	21	JUNO T265L FL SERIES	PROVIDE STANDARD TRACK IN LENGTHS AS SHOWN ON THE DRAWINGS - PROVIDE ONE TRACK FIXTURE FOR EVERY 18 INCHES OF TRACK
T2	TRACK	N/A	CEILING	DIE-CAST ALUMINUM HOUSING	SEALED LAMP	3814	4000K	STANDARD LED DRIVER NON-DIM	120	33	JUNO R610L WFL SERIES	PROVIDE STANDARD TRACK IN LENGTHS AS SHOWN ON THE DRAWINGS - PROVIDE QUANTITY OF FIXTURE AS SHOWN ON DRAWINGS
V2	2-FOOT LED VAPORTIGHT	6" WIDE X 4" DEEP	SURFACE	ONE-PIECE FIBERGLASS HOUSING	INJECTION MOLDED ACRYLIC LENS	3000	4000K	0-10 VOLT DIMMING	MULTI-VOLT	27	LITHONIA DMW2 SERIES	
V4	4-FOOT LED VAPORTIGHT	6" WIDE X 4" DEEP	CHAIN HUNG	ONE-PIECE FIBERGLASS HOUSING	INJECTION MOLDED ACRYLIC LENS	ADJUSTABLE LUMEN OUTPUT	4000K	0-10 VOLT DIMMING	MULTI-VOLT	27 - 42	LITHONIA CSVT SERIES	
WP	EXTERIOR LED WALL PACK	8" X 11" X 3" DEEP	WALL	DIE-CAST ALUMINUM HOUSING	ACRYLIC LENS	2900	4000K	ELECTRONIC	MULTI-VOLT	24	LITHONIA WPX SERIES WITH PHOTOCELL	
EXIT	LED EXIT SIGN	2" X 8" X 12"	WALL / CEILING / STEM	DIE-CAST ALUMINUM HOUSING	BRUSHED ALUMINUM FACEPLATE	N/A	N/A	ELECTRONIC	MULTI-VOLT	1	LITHONIA LQC SERIES	PROVIDE MOUNTING PLATES, CANOPIES, STEMS AS REQUIRED FOR APPLICATION, PROVIDE SINGLE AND DOUBLE FACE UNITS AS REQUIRED FOR APPLICATION

Schedule Notes:

1. Fixtures from alternative manufacturer's will be considered on a pre-bid proposed substitution basis. Substitution submittals shall include detailed cut sheets and area-by-area computer generated point-by-point photometric layouts.
2. Colors shall be selected by the Architect during the submittal process. Color choices shall be based upon the manufacturer's standard color availability.
3. Refer to drawings for fixtures to be wired to inverter circuits. Make provisions to wire fixtures independly, particularly in long runs of linear fixtures.
4. Coordinate mounting heights of pendant fixtures with Architect prior to ordering fixtures.
5. Coordinate fixture canopy options/requirements with Architect prior to ordering fixtures.
6. Fixtures are primarily recessed in a grid ceiling, however, some of the rows transition from a grid ceiling into areas that are open to the strucutre. Fixtures in the exposed areas shall be supported from the structure with aircraft cable, such that the entire row is level and true with the entire row. Refer to architectural reflected ceiling plans for these locations.

C

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COMPLETE RENOVATION/MECHANICAL UPGRADES:

Greene County Public Library

XENIA COMMUNITY LIBRARY
76 EAST MARKET STREET
XENIA, OH 45385

REVISIONS / SUBMISSIONS

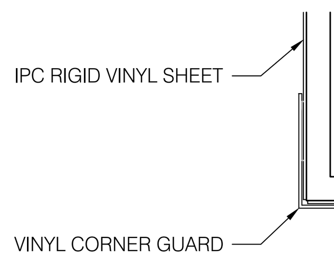
NO.	DESCRIPTION	DATE
	BID ISSUE	01/04/23
C	ADDENDUM C	01/27/23

PRELIMINARY BID NOT FOR CONSTRUCTION

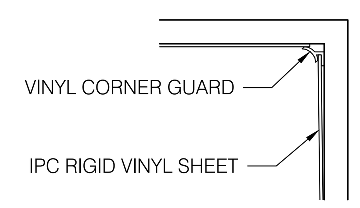
LIGHT FIXTURE SCHEDULE

Drawn By: JEP, CDG
Scale: AS NOTED
Job No.: 21-2113

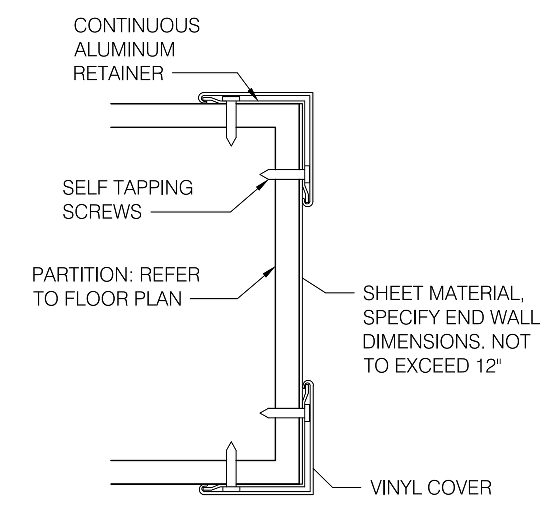
E4.3



2 I101 OUTSIDE CORNER DETAIL
SCALE: 3"=1'-0"



3 I101 INSIDE CORNER DETAIL
SCALE: 3"=1'-0"



4 I101 END CAP DETAIL
SCALE: 3"=1'-0"

NOTES THIS DRAWING:

1. FLOOR TRANSITION BY OTHER.
2. EXISTING FLOOR TO REMAIN.
3. WALL TILE IN ALL RESTROOMS. SEE I103 FOR HEIGHT.

GENERAL NOTES:

A. REFER TO T001 FOR ADDITIONAL GENERAL NOTES.
B. CARPET, LVT, AND BASE TO BE PROVIDED AND INSTALLED BY OWNER.UNLESS NOTED OTHERWISE.
C. GC TO PROVIDE LEVEL FLOOR SURFACE FOR ALL OWNER SUPPLIED FLOORING MATERIALS.
D. ALL FLOORING TRANSITIONS TO OCCUR AT DOORWAYS UNO. USE APPROPRIATE TRANSITION STRIP AS NOTED.
E. PREPARE ALL SURFACES TO RECEIVE NEW FINISHES PER MANUFACTURER'S GUIDELINES.
F. ALL FINISHES PROVIDED AND INSTALLED BY GC SHALL BE INSTALLED PER MANUFACTURER'S SPECIFICATIONS AND GUIDELINES.

FLOORING LEGEND:

LVT — LUXURY VINYL TILE BY OWNER.

C — CARPET BY OWNER.

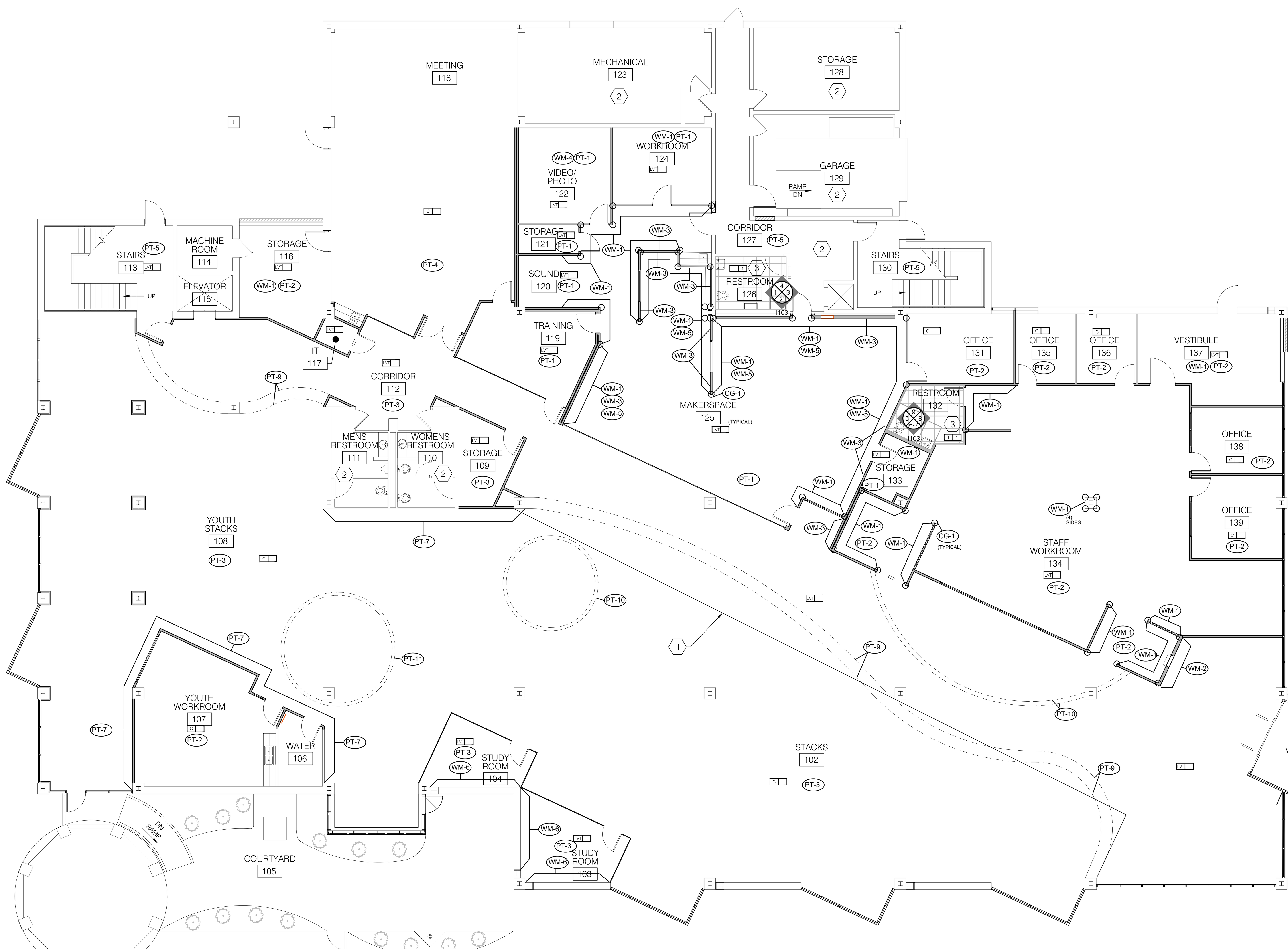
WM — WALL MATERIAL. PROVIDED BY OWNER, INSTALLED BY GC. COORDINATE WITH OWNER VENDER ON FINAL LOCATIONS PRIOR TO INSTALLATION. RE: SPECIFICATIONS FOR ADDITIONAL DETAIL.

T # — CERAMIC TILE PROVIDED AND INSTALLED BY GC. RE: SPECIFICATIONS FOR ADDITIONAL DETAIL.

CG-1 — CORNER GUARD. PROVIDED AND INSTALLED BY GC

FINISH SCHEDULE

SYMBOL	MATERIAL	SPECIFICATION	CONTACT INFORMATION	REMARKS
C-1	WALK-OFF C-TILE	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
C-2	CARPET TILE	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
C-3	CARPET TILE	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
C-4	CARPET TILE	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
C-5	CARPET TILE	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
V-1	LVT	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
V-2	LVT	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
V-3	LVT	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
V-4	LVT	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
B-1	RUBBER BASE	STYLE: TBD SIZE: 4"	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
B-2	RUBBER BASE	STYLE: TBD SIZE: 4"	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
TR-1	VINYL TRANSITION	NAME: TBD STYLE: TBD	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
TR-2	VINYL TRANSITION	NAME: TBD STYLE: TBD	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
CG-1	CORNER GUARD	STYLE: TBD COLOR: TBD	INPRO CORP. #1-800-222-5556 WWW.INPROCORP.COM	SEE PLAN FOR OUTSIDE, INSIDE, AND END CAP LOCATIONS
WM-1	WALL PROTECTION	PATTERN: PALLADIUM RIGID VINYL ROLL 48" H, COLOR:TBD	INPRO CORP. #1-800-222-5556 WWW.INPROCORP.COM	GC TO PROVIDE: CORNER GUARD, INSIDE CORNER, COLOR MATCH PROTECTOR AS RQ
WM-2	WALL PROTECTION	RICOCHET FLEXIBLE WALL PRO PASSAGE PASSAGE VERTICALLY INSTALL, COLOR: TBD	INPRO CORP. #1-800-222-5556 WWW.INPROCORP.COM	PROVIDED AND INSTALLED BY GC
WM-3	SLAT WALL PANEL	GEARWALL PANELS, COLOR: TBD	GLADIATOR GARAGE WORKS WWW.GLADIATORGARAGEWORKS.COM	PROVIDED BY OWNER, GC TO INSTALL
WM-4	ACOUSTICAL PANEL	PATTERN: MUTO SLAB. 48"W x 110"H x 1"T COLOR: TBD	SOELBERG, #1-888-228-8207 MELANIE PROULX, #1-614-314-1083	GC TO PROVIDE: Z-CLIP INSTALLATION
WM-5	ACOUSTICAL TILE	PATTERN: ECOUSTIC BOND TILE SIZE: 19.7" x 19.7" x 2.2"D, COLORS: TDB	UNIKA VAEV, #1-800-237-1625 CANDY MCDOWELL, #1-614-266-6652	GC TO PROVIDE: ECOUSTIC BOND COMPON. AND 4-WAY CLIP SYSTEM, GC PROVIDE SCREWS
WM-6	ACOUSTICAL PANEL	PATTERN: MUTO TEXTURED 42"W x 96"H x 1/2"T COLOR: TBD	SOELBERG, #1-888-228-8207 MELANIE PROULX, #1-614-314-1083	GC TO PROVIDE: Z-CLIP INSTALLATION
PT-1	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-2	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-3	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-4	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-5	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-6	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-7	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-8	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-9	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-10	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-11	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-12	CEILING PAINT	SHERWIN WILLIAMS, MATTE FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-13	CEILING PAINT	SHERWIN WILLIAMS, MATTE FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-14	CEILING PAINT	SHERWIN WILLIAMS, MATTE FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-15	CEILING PAINT	SHERWIN WILLIAMS, MATTE FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-16	PAINT PRIMER	SHERWIN WILLIAMS, MATTE FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-17	PAINT	SHERWIN WILLIAMS, SATIN FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-18	PAINT	SHERWIN WILLIAMS, SATIN FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-19	PAINT	SHERWIN WILLIAMS, SATIN FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-20	PAINT	SHERWIN WILLIAMS, SATIN FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
T-1	TILE (FLOOR)	LANDMARK CERAMICS, ATTITUDE 24" x 24" TILE, WARM SAND	AMANDA THOM, COMMERCIAL ACCT. SPECIALIST HAMILTON PARKER	PROVIDED AND INSTALLED BY GC
T-2	TILE (WALL)	DALTILE, UNITY 12" x 24" TILE, AVORIO P400	DALTILE GENERAL #877-556-5728 HTTPS://DALTILE.COM/	PROVIDED AND INSTALLED BY GC
T-3	COVE BASE TILE	DALTILE, UNITY 6" x 12" TILE, AVORIO P400	DALTILE GENERAL #877-556-5728 HTTPS://DALTILE.COM/	PROVIDED AND INSTALLED BY GC
~~SS-1~~	~~SOLID SURFACE~~	~~DUPOINT CORIAN SOLID SURFACE~~ COLOR: TBD	~~DUPOINT, GENERAL# 1-800-899-8916~~ WWW.DUPOINT.COM	~~PROVIDED AND INSTALLED BY GC~~



1 I101 FIRST FLOOR FINISH PLAN
SCALE: 3/32"=1'-0"

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Email: info@k4architecture.com

COMPLETE RENOVATION/MECHANICAL UPGRADES:
Greene County Public Library
XENIA COMMUNITY LIBRARY
76 EAST MARKET STREET
XENIA, OH 45385

REVISIONS / SUBMISSIONS		
NO.	DESCRIPTION	DATE
	BID ISSUE	01/04/23
B	ADDENDUM B	01/20/23
C	ADDENDUM C	01/27/23

PRELIMINARY BID NOT FOR CONSTRUCTION

FIRST FLOOR FINISH PLAN

Drawn By:	BBJ, TW
Scale:	AS NOTED
Job No.:	21-2113

I101

Filename : 21-2113_I101.dwg Plot Date : Jan. 30, 2023 9:25am

NOTES THIS DRAWING:

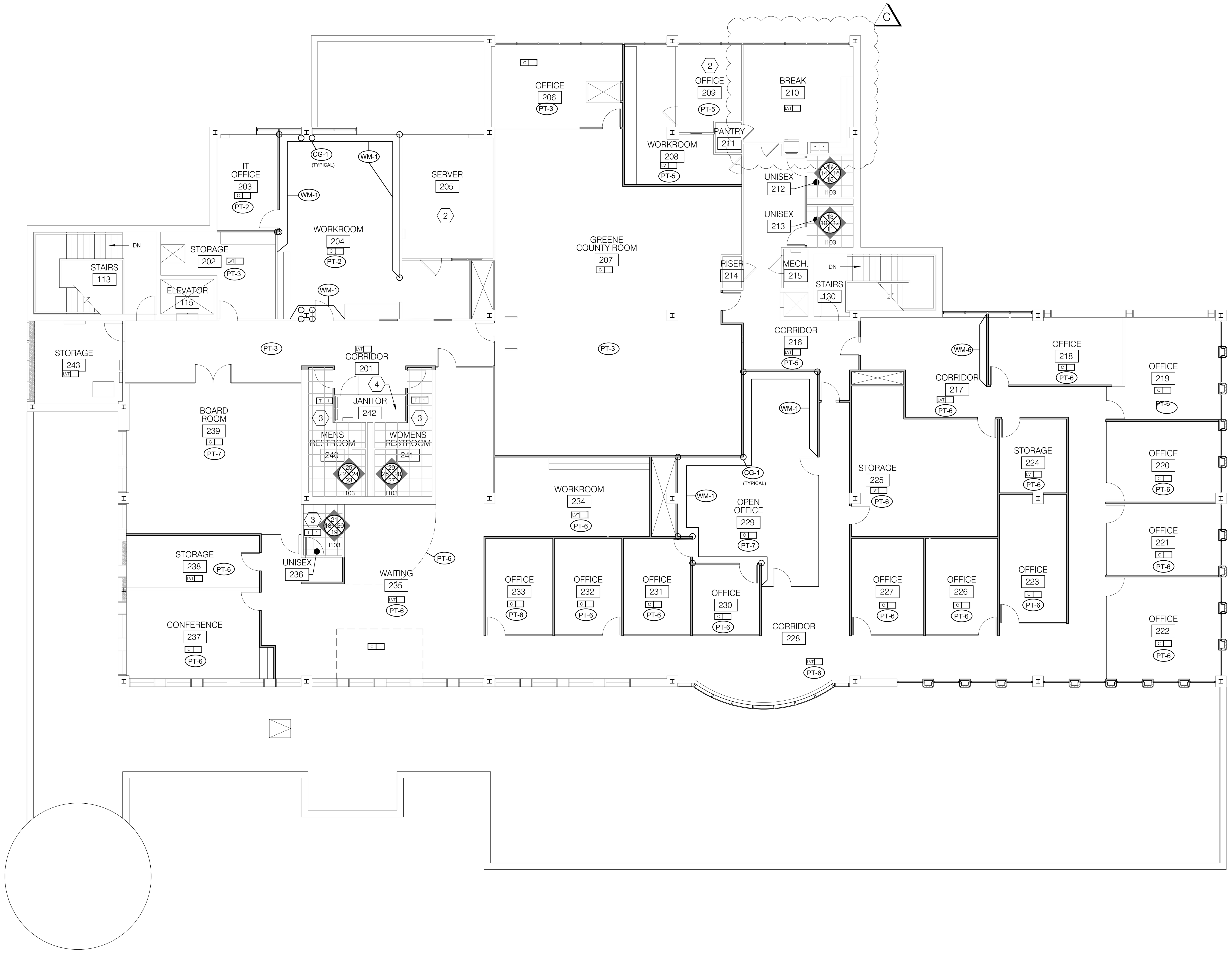
1. FLOOR TRANSITION BY OTHER.
2. EXISTING FLOOR TO REMAIN.
3. WALL TILE IN ALL RESTROOMS. SEE I103 FOR HEIGHT.
4. SEALED CONCRETE FLOOR.

GENERAL NOTES:

A. REFER TO T001 FOR ADDITIONAL GENERAL NOTES.
B. CARPET, LVT, AND BASE TO BE PROVIDED AND INSTALLED BY OWNER.
C. GC TO PROVIDE LEVEL FLOOR SURFACE FOR ALL OWNER SUPPLIED FLOORING MATERIALS.
D. ALL FLOORING TRANSITIONS TO OCCUR ST DOORWAYS UNO. USE APPROPRIATE TRANSITION STRIP AS NOTED.
E. PREPARE ALL SURFACES TO RECEIVE NEW FINISHES PER MANUFACTURER'S GUIDELINES.

FLOORING LEGEND:

LVT	LUXURY VINYL TILE BY OWNER.
C	CARPET BY OWNER.
WM	WALL MATERIAL. PROVIDED BY OWNER, INSTALLED BY GC. COORDINATE WITH OWNER VENDER ON FINAL LOCATIONS PRIOR TO INSTALLATION. RE: SPECIFICATIONS FOR ADDITIONAL DETAIL.
T #	CERAMIC TILE PROVIDED AND INSTALLED BY GC. RE: SPECIFICATIONS FOR ADDITIONAL DETAIL.
CG-1	CORNER GUARD. PROVIDED AND INSTALLED BY GC



SECOND FLOOR
FINISH PLAN
SCALE: 3/32" = 1'-0"
1 I102

FINISH SCHEDULE

SYMBOL	MATERIAL	SPECIFICATION	CONTACT INFORMATION	REMARKS
C-1	WALK-OFF C-TILE	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
C-2	CARPET TILE	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
C-3	CARPET TILE	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
C-4	CARPET TILE	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
C-5	CARPET TILE	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
V-1	LVT	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
V-2	LVT	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
V-3	LVT	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
V-4	LVT	PATTERN: TBD SIZE:	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
B-1	RUBBER BASE	STYLE: TBD SIZE: 4"	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
B-2	RUBBER BASE	STYLE: TBD SIZE: 4"	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
TR-1	VINYL TRANSITION	NAME: TBD STYLE: TBD	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
TR-2	VINYL TRANSITION	NAME: TBD STYLE: TBD	MANUFACTURER: TBD	N.I.C. PROVIDED BY OTHER
CG-1	CORNER GUARD	STYLE: TBD COLOR: TBD	INPRO CORP. #1-800-222-5556 WWW.INPROCORP.COM	SEE PLAN FOR OUTSIDE, INSIDE, AND END CAP LOCATIONS
WM-1	WALL PROTECTION	PATTERN: PALLADIUM RIGID VINYL ROLL 48" H, COLOR:TBD	INPRO CORP. #1-800-222-5556 WWW.INPROCORP.COM	GC TO PROVIDE: CORNER GUARD, INSIDE CORNER, COLOR MATCH PROTECTOR AS REQ'D
WM-2	WALL PROTECTION	RICOCHET FLEXIBLE WALL PRO PASSAGE PASSAGE VERTICALLY INSTALL, COLOR: TBD	INPRO CORP. #1-800-222-5556 WWW.INPROCORP.COM	PROVIDED AND INSTALLED BY GC
WM-3	SLAT WALL PANEL	GEARWALL PANELS, COLOR: TBD	GLADIATOR GARAGE WORKS WWW.GLADIATORGARAGEWORKS.COM	PROVIDED BY OWNER, GC TO INSTALL
WM-4	ACOUSTICAL PANEL	PATTERN: MUTO SLAB. 48"W x 110"H x 1"T COLOR: TBD	SOELBERG, #1-888-228-8207 MELANIE PROULX, #1-614-314-1083	GC TO PROVIDE: Z-CLIP INSTALLATION
WM-5	ACOUSTICAL TILE	PATTERN: ECOUSTIC BOND TILE SIZE: 19.7" x 19.7" x 2.2"D, COLORS: TDB	UNIKA VAEV, #1-800-237-1625 CANDY MCDOWELL, #1-614-266-6652	GC TO PROVIDE: ECOUSTIC BOND COMPON. AND 4-WAY CLIP SYSTEM, GC PTOVIDE SCREWS
WM-6	ACOUSTICAL PANEL	PATTERN: MUTO TEXTURED 42"W x 96"H x 1/2"T COLOR: TBD	SOELBERG, #1-888-228-8207 MELANIE PROULX, #1-614-314-1083	GC TO PROVIDE: Z-CLIP INSTALLATION
PT-1	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-2	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-3	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-4	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-5	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-6	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-7	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-8	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-9	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-10	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-11	WALL PAINT	SHERWIN WILLIAMS, EGGSHELL FINISH COLOR: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-12	CEILING PAINT	SHERWIN WILLIAMS, MATTE FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-13	CEILING PAINT	SHERWIN WILLIAMS, MATTE FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-14	CEILING PAINT	SHERWIN WILLIAMS, MATTE FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-15	CEILING PAINT	SHERWIN WILLIAMS, MATTE FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-16	PAINT PRIMER	SHERWIN WILLIAMS, MATTE FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-17	PAINT	SHERWIN WILLIAMS, SATIN FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-18	PAINT	SHERWIN WILLIAMS, SATIN FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-19	PAINT	SHERWIN WILLIAMS, SATIN FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
PT-20	PAINT	SHERWIN WILLIAMS, SATIN FINISH COLOR: TBD LOCAL: TBD	SHERWIN WILLIAMS,#1-800-4SHERWIN WWW.SHERWIN-WILLIAMS.COM	PROVIDED AND INSTALLED BY GC
T-1	TILE (FLOOR)	LANDMARK CERAMICS, ATTITUDE 24" x 24" TILE, WARM SAND	AMANDA THOM, COMMERCIAL ACCT. SPECIALIST HAMILTON PARKER	PROVIDED AND INSTALLED BY GC
T-2	TILE (WALL)	DALTILE, UNITY 12" x 24" TILE, AVORIO P400	DALTILE GENERAL #877-556-5728 HTTPS://DALTILE.COM/	PROVIDED AND INSTALLED BY GC
T-3	COVE BASE TILE	DALTILE, UNITY 6" x 12" TILE, AVORIO P400	DALTILE GENERAL #877-556-5728 HTTPS://DALTILE.COM/	PROVIDED AND INSTALLED BY GC
SS-1	SOLID SURFACE	DUPOINT CORIAN SOLID SURFACE COLOR: TBD	DUPOINT, GENERAL# 1-800-899-8916 WWW.DUPOINT.COM	PROVIDED AND INSTALLED BY GC

C

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COMPLETE RENOVATION/MECHANICAL UPGRADES:
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76 EAST MARKET STREET
XENIA, OH 45385

REVISIONS / SUBMISSIONS		
NO.	DESCRIPTION	DATE
	BID ISSUE	01/04/23
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PRELIMINARY BID
NOT FOR
CONSTRUCTION

SECOND FLOOR
FINISH PLAN

Drawn By:	BBJ, TW
Scale:	AS NOTED
Job No.:	21-2113

I102

Filename : 21-2113_I101.dwg Plot Date : Jan. 30, 2023 9:27am