ATS+R

PLANNERS + ARCHITECTS + ENGINEERS

MADISON ELEMENTARY SCHOOL
HVAC REPLACEMENT AND
DEFERRED MAINTENANCE
PHASE 3

650 Territorial Road Northeast
Blaine, Minnesota 55434

FOR

ANOKA-HENNEPIN SCHOOL DISTRICT 11
2727 NORTH FERRY STREET
ANOKA, MINNESOTA

ANOKA-HENNEPIN AREA SCHOOLS
BID NUMBER: 22005B

ATS&R PROJECT NUMBER 19040.2

VOLUME NO. 2

MECHANICAL 21, 22 AND 23
ELECTRICAL 26, 27, 28 AND 29

SET _____

ARCHITECTURE + ENGINEERING + PLANNING + TECHNOLOGY + LANDSCAPE ARCHITECTURE + INTERIOR DESIGN
8501 Golden Valley Road | Suite 300 | Minneapolis, MN 55427 | office 763.545.3731 | fax 763.525.3289 | www.atsr.com

19040.2

DOCUMENT 00 01 01

TITLE PAGE

PROJECT MANUAL FOR:

MADISON ELEMENTARY SCHOOL
HVAC REPLACEMENT AND
DEFERRED MAINTENANCE - PHASE 3
650 Territorial Road Northeast
Blaine, Minnesota 55427-4414

OWNER:

ANOKA-HENNEPIN SCHOOL DISTRICT 11
2727 North Ferry Street
Anoka, MN 55303

ARCHITECT:
MECHANICAL ENGINEER:
ELECTRICAL ENGINEER:

ARMSTRONG, TORSETH, SKOLD, & RYDEEN, INC.
8501 Golden Valley Road, Suite 300
Minneapolis, Minnesota 55427-4414
Telephone Number: 763-545-3731
Fax Number: 763-525-3289
Project Architect: David M. Maroney, AIA
Mechanical Engineer: Blayne J. Parkos, PE
Electrical Engineer: Nicholas Achina, PE

STRUCTURAL ENGINEER:

IMEG CORPORATION
12755 Highway 55, Suite 100
Minneapolis, Minnesota 55441
Telephone Number: 763-545-9196
Fax Number: 763-541-0056
Structural Engineer: Timothy G. LaBissoniere, PE

PROJECT NUMBER: 19040.2

DATE OF DOCUMENT: December 3, 2021

ANOKA-HENNEPIN SCHOOLS
BID NUMBER: 22005B

END OF DOCUMENT

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CERTIFICATION PAGE

PROJECT:

MADISON ELEMENTARY SCHOOL
HVAC REPLACEMENT AND
DEFERRED MAINTENANCE - PHASE 3
650 Territorial Road Northeast
Blaine, Minnesota 55427-4414

ARCHITECT'S CERTIFICATION:

I hereby certify that this Plan, Specification, or Report was prepared by me or under my direct supervision and that I am a duly Licensed Architect under the laws of the State of Minnesota.

Name David M. Maroney, AIA

Signature

Date December 3, 2021 License No. 20992

STRUCTURAL ENGINEER'S CERTIFICATION:

I hereby certify that this Plan, Specification, or Report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Name Timothy G. LaBissoniere, PE

Signature

Date December 3, 2021 License No. 21387

MECHANICAL ENGINEER'S CERTIFICATION:

I hereby certify that this Plan, Specification, or Report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Name Blayne J. Parkos, PE

Signature

Date December 3, 2021 License No. 46630

ELECTRICAL ENGINEER'S CERTIFICATION:

I hereby certify that this Plan, Specification, or Report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Name Nicholas Achina, PE

Signature

Date December 3, 2021 License No. 40408

END OF DOCUMENT

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END OF DOCUMENT

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LIST OF DRAWINGS

PART 1 - GENERAL

1.01 DEFINITION

A. **Contract Drawings:**

1. Drawings issued for bidding as included in the following List of Drawings.

2. Revision Drawings issued by Addenda during bidding and Supplemental Drawings issued by Architect during execution of the Work to clarify, amplify, or otherwise modify the Contract Drawings.

B. **Architectural Drawings:**

A0.0 Title Sheet

A1.1 Reference and Code Analysis Plan
A2.1 Demolition Plan
A3.1 Floor Plan
A7.1 Roof Plan and Details
A8.1 Miscellaneous Details
A11.1 Interior Elevations
A11.2 Interior Elevations
A11.3 Interior Elevations
A11.4 Interior Elevations
A13.1 Reflected Ceiling Plan

C. **Structural Drawings:**

S1.0 General Notes and Special Inspection Notes
S2.0 Partial Roof Framing Plan and Sections

G. **Mechanical Drawings:**

M0.0 Mechanical Title Sheet

MD4.1 First Floor Plumbing and Hydronic Demolition Plans
MD5.1 Ventilation Demolition Plan
M2.1 Fire Protection Plan
M4.0 Tunnel Hydronic Plans
M4.1 First Floor Plumbing and Hydronic Plans
M5.1 First Floor Ventilation Plan
M5.2 Media Center Mechanical Plans
M6.1 1/8 Scale Mechanical Roof Plan
M6.2 Mechanical Sections
M7.1 Mechanical Details
M9.1 Mechanical Equipment Schedules
M10.1 Mechanical Control Diagrams
M10.2 Mechanical Control Diagrams
M11.1 Mechanical Alternates

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D. **Electrical Drawings:**

E0.0	Electrical Title Sheet and Symbol Schedule
ED.1	Electrical Demolition Plan
E2.1	Lighting Plan
E3.1	Power Plan
E4.1	Systems Floor Plan
E6.1	Main Floor Motors and Panelboards Plan
E7.1	Technology Symbol Schedule and Details
E8.1	Electrical Schedules and Details

PART 2 - PRODUCTS Not Used

PART 3 - EXECUTION Not Used

END OF DOCUMENT

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CALL FOR BIDS

PROJECT IDENTIFICATION: Anoka-Hennepin School District will be receiving sealed bids for Madison Elementary School HVAC Replacement and Deferred Maintenance – Phase 3, located at 650 Territorial Road Northeast, Blaine, Minnesota 55434, in accordance with the Bidding Documents prepared by Armstrong, Torseth, Skold & Rydeen, Inc., Architects and Engineers, 8501 Golden Valley Road, Suite 300, Minneapolis, MN 55427-4414.

PROJECT DESCRIPTION: Project consists of removing existing steam radiation and unit ventilators. Providing roof mounted energy recovery units with condensing units will be used to provide ventilation air to each space. The existing pneumatic temperature control system will be replaced with a direct digital control system. Architectural work to include acoustical ceiling panel replacement, floor polishing, light fixture replacement, marker board replacement, wall repair, wall painting, casework replacement, and patching required for Mechanical Work.

TYPE OF BIDS: Single Lump Sum Bids will be received for the Work being included under the Contract.

BID DATE: Bids must be received on or before January 12, 2022 at 2:00 PM.

DELIVERY AND OPENING OF BIDS: Bids shall be delivered to and will be opened at the Anoka-Hennepin School District Educational Service Center, Purchasing Office, located at 2727 North Ferry Street, Anoka, Minnesota, Entrance #1. ***Bids will be opened and read aloud immediately after the specified time of closure for the bidding period. This will be conducted live through the use of the google meet platform. Those interested in attending the bid opening, may do so virtually utilizing the link provided below or calling in.***

Google Meet joining info
Video call link: https://meet.google.com/inb-acmm-jbs
Or dial: (US) +1 505-445-7788 PIN: 154 036 713#

BID SECURITY: Bids shall be accompanied by bid security for 5 percent of the Base Bid submitted, made payable to the Owner.

EXAMINATION OF DOCUMENTS: Bidding Documents, including Drawings, Project Manual and addenda, may be examined at Architects' office and at following locations:

Minnesota Builders Exchange
1123 Glenwood Avenue
Minneapolis, MN 55405
Telephone Number: 612-381-2620
Fax Number: 612-381-2621

Franz Reprographics
2781 Freeway Blvd.
Brooklyn Center, MN 55430
Telephone Number: 763-503-3401
Fax Number: 763-503-3409

PROCUREMENT OF DOCUMENTS BY BIDDERS: A Bidder may view and order bid documents by going to the Franz Reprographics web site at www.franzrepro.com and selecting the **Franz Public Plan Room**. Please select your project from the list of public projects. Once you have selected the project, please review the **Bid Details** for information on ordering documents and the cost of the non-refundable purchase price. To receive **Bid Notices, Bid Addendums, Construction Bulletins, Shipped Order Confirmations, and Electronic Downloads,** for this project, you must place the following email address in your list of Outlook Contacts and indicate that it is a **Safe Sender: notice@designbidbuild.net** These notifications are sent from this email address. If you do not do this, your email server may block the receipt of these notifications. ***Please contact Franz Reprographics, 763-503-3401, for help accessing the Online Plan Room or ordering non-refundable documents.***

Procurement of Addenda: Architect will issue copies of Addenda to Franz Repro to post in the Plan Room and online.

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DOCUMENT 00 11 13

PRE-BID MEETING: A Pre-Bid Meeting for Bidders will be held on December 14, 2021 @ 4:00 PM. Local time. Participants shall meet at 650 Territorial Road Northeast, Blaine, Minnesota 55434, (Tour of the Site will be conducted after the meeting.)

TIME OF COMMENCEMENT AND COMPLETION: Work may commence on June 13, 2022 and Substantially Complete on/or before August 13, 2022.

BONDING REQUIREMENTS: Contractor will be required to provide a Performance Bond and a Payment Bond each in an amount of 100 percent of Contract Amount.

WAGE DETERMINATION REQUIREMENTS: Contract is subject to compliance with the applicable Schedule of Prevailing Wages issued by the Minnesota Department of Labor and Industry.

RESPONSIBLE CONTRACTOR REQUIREMENTS: Provide all State required Responsible Contractor Forms with your bid.

BIDS REQUESTED BY:

Anoka-Hennepin School District
Educational Service Center
Purchasing Office located at:
2727 North Ferry Street, Entrance #1
Anoka, MN 55303

Tiffany Audette, Purchasing Manager

Bid Number: 22005B

END OF DOCUMENT

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SECTION 21 00 00

FIRE SUPPRESSION - GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Work included under this Division shall consist of furnishing labor and materials necessary for the installation of the work called for under the Mechanical Contract as listed in the Instruction to Bidders, as specified, and as shown on Drawings to provide a complete, operable and approved system.

1. Job Progress: Contractor shall provide sufficient workers and materials to keep pace with the construction schedule. Contractor shall place orders for equipment such that job progress is not slowed due to late delivery and shall confirm delivery dates with suppliers.

2. Coordination: Contractor shall coordinate trades to install systems in the space provided within the structure. Where required, Contractor shall remove and reinstall existing work to allow for a congruous installation. Install systems and materials for ease of maintenance. Equipment arrangements shall provide at least the minimum clearances as recommended by equipment manufacturer to facilitate proper maintenance and servicing of system.

    a. Deviations in minimum clearance requirements shall be permitted only upon prior written authorization from the Architect/Engineer.

B. **Related Sections:**

1. Section 01 11 00: Summary of Work
2. Section 01 23 00: Alternates
3. Section 01 33 00: Submittals Procedures
4. Section 01 61 00: Common Product Requirements
5. Section 01 73 29: Cutting and Patching
6. Section 01 77 00: Closeout Procedures

C. **Drawings Use and Interpretation:**

1. Drawings are diagrammatic and indicate the general arrangement of systems and equipment, unless indicated otherwise by dimensions or Detail Drawings. For exact locations of building elements, refer to dimensioned Architectural/Structural Drawings; However, field measurements take precedence over Dimensioned Drawings. The installation of all systems and equipment is subject to clarification as indicated in Division 1, GENERAL REQUIREMENTS.

2. Generally, layout pipelines requiring drainage first, followed by large pipe mains, ductwork and electrical conduit. Follow this procedure for an orderly installation but not to establish precedence of one trade over another.

3. Equipment outlines shown on Detail Drawings or dimensions indicated anywhere on the Drawings are limiting dimensions. Equipment exceeding approximate dimensions indicated by equipment outlines on Detail Drawings and any equipment or arrangements that reduce indicated clearances or exceed specific equipment dimensions may not be used.

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D. **CADD Drawings:**

1. After an award of Contract, Contractors may request electronic copies of our CADD Drawings.

2. Request for copies of the CADD Drawings shall be in writing and shall clearly indicate the specific sheets of the Drawings which are being ordered.

3. The following pricing shall apply:

   a. $100.00 Per Sheet for Unit Information (i.e., Fire Sprinkler)

   b. $100.00 Per Reference Plan / Building Plan per Floor

E. **Mechanical Project Conditions:**

1. The following are Mechanical project conditions that are requirements of this Project:

   a. Architect/Engineer shall make (1) review and allow (1) resubmittal review if required for each Shop Drawing, product data, sample or similar submittal. If additional resubmittals are required due to the Contractor's failure to comply with the Contract Documents, the Architect/Engineer's expense for reviewing the additional resubmittals shall be charged to the Contractor and such payment shall be accomplished by a deductive Change Order to the Contract.

   b. Contractor shall complete all items on the punchlist accompanying the Certificate of Substantial Completion in (30) calendar days. Contractor will submit a punchlist completion schedule within (10) days of receipt of the Certificate of Substantial Completion. Any cost incurred by the Architect, Architect's consultants, or the Owner's consultants (after 30 calendar days of Substantial Completion) to close out the Project will be deducted from the Contractor's final payment.

   c. Architect and Owner's Commissioning Agent shall make (1) Substantial Completion inspection and (1) Final Completion Inspection. If additional inspections are required due to the Contractor's failure to complete previously listed corrective or uncompleted work, the Architect and the Owner's Commissioning Agent expenses for conducting such reinspection and related time in processing, reviewing and revision or requirements shall be charged to the Contractor and such payment shall be accomplished by a deductive Change Order to the Contract.

1.02 REFERENCES

A. **American National Standard Institute (ANSI):**

1. ANSI B31.1, Pressure Piping - Power Piping

B. **American Society of Mechanical Engineers (ASME):**

1. Boiler and Pressure Vessel Code: Section IX, Welding and Brazing Qualifications

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C. **ASTM International:**

1. ASTM R84-81, Surface Burning Characteristics of Building Materials

D. **American Water Works Association (AWWA)**

E. **Manufacturer's Standardization Society (MSS of the Valve and Fittings Industry, Inc.):**

1. MSS SP-58-1975, Pipe Hangers and Supports Materials, Design, and Manufacture
2. MSS SP-69-1976, Pipe Hangers and Supports Selection and Application

F. **National Electrical Manufacturers Association (NEMA)**

G. **National Fire Protection Association (NFPA):**

1. NFPA 13A, Inspection, Testing, and Maintenance of Sprinkler Systems
2. NFPA 90A, Air Conditioning and Ventilation Systems
3. NFPA 101, Life Safety Code

H. **Steel Tank Institute (STI)**

I. **Underwriters Laboratories (UL)**

1.03 DESIGN INTENT

A. **Fire Protection:**

1. Modifications to the wet pipe fire sprinkler system with various zones throughout the entire building.

2. Sprinkler heads are normally semi-recessed chrome plated in classrooms and offices. Flat plate (concealed) heads are used in high impact areas like corridors, toilet rooms and locker rooms. Upright heads are used in exposed areas. Coated heads on galvanized piping is used in wet environments.

1.04 EXISTING SYSTEMS, EQUIPMENT, AND MATERIAL

A. **Hazardous Materials:** Under a previous contract, asbestos-bearing materials have been removed or encapsulated. If asbestos-bearing materials, mercury-containing devices (such as thermostats, pneumatic-electric switches), or other hazardous materials are encountered, do not proceed with work in that location, but immediately inform the Owner so appropriate action can be taken.

B. **Remodeling:** Where relocations of existing equipment, and piping systems and materials is necessary in areas providing uninterruptible services, schedule the work for minimal down time during a slack period, if possible. Assign an adequate crew to accomplish the job in least possible time. Prefabricate and install interconnecting portions of these systems prior to shut-down for final connections.

1. Locate existing piping and make connection where required or where shown on the Drawings. Do not cut into existing services without verifying with the Owner that the pipe involved is the desired service. In any area where work performed under Division 21 is the only work involved, restore the area to its original condition upon completion of work.

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2. Maintain all existing services and equipment, unless otherwise shown on Drawings.

3. Perform work that interrupts any service (this includes cutting into existing lines for new connections) at times (usually night) to cause the least interference to the normal operation of the building. Anticipate scheduling work at periods which will result in additional construction cost, such as nights and weekends, and include cost in the proposal.

4. Inform the building engineering staff in advance of any shut-off that will occur and give an estimate of duration. Only after the engineering staff is fully informed and has agreed to the schedule of shut-offs, can the work then proceed accordingly.

5. All diffusers, coils, valves, thermostats, fixtures, piping, and other valuable equipment shall remain property of the Owner, except where noted otherwise, and stored on the site where directed.

C. **Connections:** Contractor shall field verify and inspect existing buildings for connections to existing systems, equipment, and materials designated, on Drawings or in Specifications, to be used.

1. Requests for additional compensation will not be considered when such occurrence is the result of existing conditions.

1.05 SUBMITTALS

A. **General Requirements:** Provide submittals in accordance with Section 01 33 00.

B. **Operating Characteristics:** Submittals shall list actual proposed capacities of equipment submitted. Contractor shall indicate actual operating characteristics of proposed equipment at specified design conditions in the submittal.

C. **Review:** Review of Shop Drawings and other submittals will be general in nature and shall not be considered:

1. As permitting any departure from Contract requirements.

2. As relieving Contractor of responsibility for errors, including details, quantities, dimensions, and materials.

3. Contractor is responsible for reviewing all information in Shop Drawings related to the mechanical systems. Information includes, but is not limited to, the following: size, dimensions, electrical power requirements, hp, CFM, GPM, BTU, sound, system operating steam and/or gas pressure, pressure drops (water and air), and tonnage.

4. Contractor shall highlight all differences between that which is being submitted and that which was specified.

D. **Samples:** Provide samples of material or equipment proposed to be furnished, if requested. Samples shall become the property of the Architect/Engineer and will be returned only when accompanied by a written request to do so.

E. **Record Drawings:** Refer to requirements indicated in Section 01 77 00.

1. Record Drawings shall be provided in a hard copy and an electronic copy (PDF format).

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F. **Compatibility of Equipment:** Contractor shall have full responsibility of component parts of the fire suppression system to ensure that new equipment, integrated with existing equipment and systems, will perform and operate in accordance with requirements of the Specifications without excessive or unusual service or maintenance requirements.

1. Should damage be sustained to existing fixtures, materials or equipment to be reused, relocated or to remain, the same shall be replaced with new material or equipment of equal or better quality as the Architect/Engineer directs.

2. It shall be the Contractor's responsibility to determine that changes in physical dimensions, access for maintenance, service line connections, structural supports, and vibration devices for substitute (approved equal) equipment are acceptable in the space provided for equipment and that performance characteristics are at least equal to base specification for equipment utilized from the substitutes (approved equals) listed.

3. Increased costs to provide additions or revisions required by acceptable manufactures not used as basis of design and substitute (approved equal) manufactures shall be the sole responsibility of this Contractor. Examples of additions or revision shall be as follows, but is not inclusive of all items:

   a. Electrical service connections revisions
   b. Additional equipment
   c. Wall and room layout revisions
   d. Structural support revisions
   e. Screen wall revisions

1.06 QUALITY ASSURANCE

A. **Qualifications:** Where equipment is specified by manufacturer, brand name or catalog number, this shall establish the standard of quality and style of the product to be provided under the Contract.

1. Where (2) or more units of the same kind of equipment are required, they shall be products of a single manufacturer. Mixing and matching of various manufacturer's like or similar components shall not be permitted.

B. **Regulatory Requirements:**

1. State Building Code

2. National Electric Code

3. Local Codes and Ordinances

1.07 WARRANTY

A. **General Requirements:** Equipment furnished under this Contract shall have a 1-year warranty on parts and labor beginning at the date of Substantial Completion, unless a longer period is specified in the equipment specification section.

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PART 2 - PRODUCTS

2.01 WALL, FLOOR, AND CEILING OPENINGS

A. **General Requirements:** This Contractor shall be responsible for locating chases and openings required for work in the General Construction of the building.

B. **Chases and Openings:** Applicable Contractor shall be required to leave chases and openings in walls, floors, ceilings, and partitions where shown on Drawings or otherwise necessary to receive fire suppression work.

2.02 SLEEVES

A. **General Requirements:** Provide sleeves in conjunction with pipes passing through concrete or masonry walls, partitions, and slabs. Provide sleeves in mechanical equipment rooms and chases to prevent water flooding from floor to floor, in addition to separating piping from building structure.

1. Sleeves shall extend through full thickness of walls and slabs and shall be at least (2) pipe diameters larger than the pipe passing through.

2. Core-drilled holes through solid masonry, concrete beams, or filled core concrete block walls, do not require sleeves.

3. Where pipes pass through existing walls or floors, holes shall be core-drilled.

B. **Pipe Sleeves:**

1. Exterior Walls: Sleeves shall be standard weight steel pipe. Install sleeves in exterior walls and floors below grade with approved caulking between sleeves and piping to make it waterproof. Plastic sleeves shall not be used.

2. Floors: Sleeves shall be standard weight steel pipe vertical pipe sleeves through floors shall have space between pipe and sleeve packed with an approved fire stop material flush with top of sleeve to make a watertight and fire rated joint.

3. Interior Sleeves: Sleeves shall be standard weight steel pipe. Piping through walls of adjacent rooms shall have soundproof packing (closed cell rod and sound caulking) in non-rated walls and an approved fire stop material in fire rated walls.

4. Fire Rated Wall and Floor Openings: Piping passing through fire rated walls and floors shall be provided as an Underwriters' Laboratories classified pipe and pipe sleeve assembly. Pipe and pipe sleeve assembly shall meet or exceed fire rating of wall and floor which the pipe passes through.

   a. Refer to Section 21 05 55, Penetration Sealants for Fire Suppression.

C. **Kitchen Walls (Food Storage, Preparation, Serving, and Clean-Up Areas):** Piping through Kitchen walls shall be caulked between sleeves and piping to make it waterproof. Plastic sleeves shall not be used. Conduits through Kitchen walls shall be caulked waterproof.

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PART 3 - EXECUTION

3.01 EXAMINATION

A. **Verification of Conditions:**

1. On-Site Review: Contractor shall visit site to become thoroughly acquainted with existing conditions of site and services.

2. Existing Active Services: When encountered in Work, Contractor shall protect, brace or support pneumatic tubing, existing active sewers, water, gas, ductwork, or other services, where required, for proper execution of Work.

   a. If existing active services not indicated on Drawings are encountered, Contractor shall relocate and brace these services at no additional cost to Owner.

3. Inactive Services: If encountered in Work, Contractor, as appropriate, shall cap or plug inactive pipes, ducts, and temperature control wiring at no additional cost to Owner.

4. Responsibility: Liability for repairs or replacement of damaged or defective materials, including, but not limited to, property damage resulting from negligence or other causes, shall be the Contractor's sole responsibility until work has been accepted by Architect/ Engineer and Owner.

3.02 PREPARATION

A. **General:** After delivery, and before and after installation, equipment shall be protected against theft, injury or damage.

1. Coat polished or plate metal parts with Vaseline immediately after installation. Protect equipment outlets, pipe, and conduit openings with temporary plugs, caps or burlap as required to prevent filling with construction dirt.

3.03 CUTTING AND PATCHING

A. **General Requirements:** Cutting and patching shall be held to practical minimum consistent with good construction practice by properly locating and leaving sleeves and boxes, or notifying applicable Contractor of openings, where required, as construction progresses.

1. Necessary cutting and patching of walls, floors, partitions, and ceilings, as required for the proper installation of work under this Contract, shall be the sole responsibility of this Contractor. Perform cutting and patching in such a manner as to leave no visible trace and to return the part affected to the condition of undisturbed work using the same material as presently installed. Cutting and patching shall be performed by workers experienced, skilled, and licensed for the particular type of work involved. Inferior work will not be accepted.

2. Contractor is responsible for patching all holes/openings left in existing floors, walls, ceilings, and roofs where mechanical equipment such as pipe, ductwork, etc. has been removed unless noted otherwise on the drawings. Patching shall be performed by workers experienced, skilled, and licensed for the particular type of work involved. Inferior work will not be accepted.

B. **Existing Conditions:** Patch pavements to match existing conditions. Labor and materials required to replace and rebuild parts cut or injured shall be furnished and installed by this Contractor.

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3.04 INSTALLATION

A. **Floor, Wall, and Ceiling Plates:** Where uncovered exposed pipes pass through floors, walls or ceilings in finished rooms and inside casework, fit with approved type chrome plated metal plate.

1. Plastic escutcheon plates shall not be permitted.

B. **Lubrication:** After systems and equipment have been installed and just prior to building acceptance, properly lubricate motors and equipment installed for this Project per manufacturer's recommendations.

3.05 CLEANING

A. **Housekeeping, Cleaning, and Storage:** Remove from the building and site, scrap material, temporary building, packaging material, miscellaneous debris, and dirt on a regular schedule, or as required, and in accordance with Architect/Engineer's direction, to maintain building in a reasonably clean, workable condition during construction.

1. Cutting oil and steel shavings shall be caught in a suitable container to ensure final finish material in building will not be marred or damaged.

2. Upon completion of work and before final inspection, Contractor shall remove plaster, paint, rust, stickers, and shipping tags from installed equipment.

a. Clean foreign matter from installed equipment and remove dirt and debris, in connection with work, from building.

3.06 LIST OF CONSTRUCTION CLOSEOUT DOCUMENTS

A. **General:** Contractor and its Subcontractors should proceed immediately to fully complete the work as listed in Appendix 'A' at the end of this Section. Contractor responsible shall initial and date the "Contractor Completed" column after each item as it is completed and forward a copy of the fully completed punch list to the Engineer for its final approval.

(Refer to Following Page for Appendix)

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Appendix 'A'

Section	Document Description	Contractor Date Comp./By	ATS&R Approved
21 10 00	Submit (3) copies of As-Built Fire Protection Shop Drawings.	_____/_____	_____
21 10 00	Submit (3) copies of hydrostatic test reports for each system.	_____/_____	_____
21 10 00	Submit (3) copies of Operation and Maintenance for fire protection system.	_____/_____	_____
21 10 00	Submit written material and workmanship warranty for fire protection system.	_____/_____	_____
21 10 00	Provide letter/certification from state/city that fire protection system is accepted.	_____/_____	_____
21 10 00	Document that at least (1) system orientation seminar for Owner's personnel has been provided on fire protection system.	_____/_____	_____
21 10 00	Document that fire protection system has been flushed clean of all foreign matter.	_____/_____	_____

END OF SECTION

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OPERATION AND MAINTENANCE OF FIRE SUPPRESSION

PART 1 - GENERAL

1.01 OPERATION AND MAINTENANCE MANUALS

A. **General Requirements**: This Section is in addition to the Division 1 O&M Manual requirements.

1. Operations and Maintenance (O&M) Manuals shall be submitted in paper and electronic formats. Each Contractor shall complete and submit (3) copies of each O&M Manual section (main tab) within (30) days of the respective submittal acceptance. These will be reviewed for compliance and acceptability by Architect/Engineer.

   a. Electronic format shall be provided on CD in format acceptable to the Owner.

2. (60) days prior to the original scheduled Substantial Completion date, each Contractor shall compile the individual O&M Manual sections and submit (3) complete copies to Architect/Engineer. Contractor shall compile O&M Manuals for every piece of equipment and building operating system according to the following requirements:

   a. Format: 8 1/2 inch by 11 inch loose leaf binders. Each binder shall be clearly labeled on the spine. Use as many as required. Do not overload binders. Use dividers with permanently marked tabs of card stock separating each section and subsection. Tab labels must be easily readable and not handwritten.

   b. Each binder shall be composed of:

      1) Title Page

      2) Table of Contents

      3) Main Tab for each Specifications Section

      4) Sub-Tab for each Piece of Major Equipment (or group, if small or numerous)

   c. Each sub-tab shall be similar to the main tab for the Specification Section, but of a different color. Inside each equipment sub-tab shall be the following sections, in the given order, divided by a double-weight colored sheet labeled with the title of the section.

      1) Contractor: Record the name, address and telephone number of the manufacturer and installing Contractor and the 24-hour number for emergency service for all equipment in this sub-tab, identified by equipment.

      2) Submittal and Product Data: Section shall include all approved submittal data, cut sheets, and appropriate Shop Drawings. If a submittal was not required for approval, include descriptive product data.

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3) Operation and Maintenance Instructions: Shall be the written manufacturer's data with the model and features of this installation clearly marked and edited to omit reference to products or data not applicable to this installation. Section shall include data on the following:

   a) Installation, startup and break-in instructions and reports.

   b) All starting, normal shutdown, emergency shutdown, manual operations, seasonal changeover and normal operating procedures and data, including any special limitations.

   c) O&M and installation instructions that were shipped with the unit.

   d) Preventive maintenance and service procedures and schedules.

   e) Troubleshooting procedures.

   f) A parts list, edited to omit reference to items that do not apply to this installation.

   g) A list of any special tools required to service or maintain the equipment.

   h) Warranty, which clearly lists conditions to be maintained to keep warranty in effect and conditions that would affect the validity of the warranty.

   i) Any service contracts issued.

   j) A Maintenance and Lubrication Schedule (see Appendix 'B' at end of this section for a blank form) shall include each motor, function, control location, fuse location, type of lubricant, and rate of lubrication in accordance with manufacturer.

4) Specifications: Section is comprised of the component or system specification section copied and inserted, including all Addenda.

5) System Description: Section shall include the individual equipment portion of the overall system design documentation narrative. It will contain simplified professionally drawn single line system diagrams on 8 1/2 inch by 11 inch or 11 inch by 17 inch sheets, showing all controls, connections, and interfaces.

6) Preventive Maintenance Instructions: Section shall include condensed, typewritten excerpts from the manufacturer's written instructions for weekly, monthly, quarterly, annual, or other maintenance schedule. This summary shall be prepared by the responsible Contractor with help from the equipment supplier. It shall be prepared for all installed equipment. Section should include checklists for each task required.

7) Supplemental Data: When manufacturer's standard printed data is not available or the information necessary for a proper understanding and O&M of equipment or systems is missing, supplemental data shall be developed by the responsible Contractor for the equipment. This data shall be written text and simple schematic Drawings.

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8) Include a warranty letter in the O&M Manual, to include the starting date(s) of warranty period(s) (including delayed start warranties and extended warranties) and duration of warranty periods. Warranty date should correspond to Substantial Completion date established by the Contract Documents.

1.02 INSTRUCTION

A. **General Requirements:** At the completion of the Project, when all systems are operating, the Contractor or its representative shall provide a minimum of 1/2 day instruction period for Owner's personnel on the fire suppression equipment.

1. Instruction shall take the form of classroom sessions to introduce the fire suppression equipment operation, maintenance, and management personnel to the manuals, drawings, and other documents and aids available to operate and maintain the fire suppression equipment and systems.

2. Instruction shall provide sufficient information to allow Owner's personnel to understand and operate all equipment and components.

3. Contractor shall coordinate and assist Owner to allow for video taping of on-site training if Owner chooses to do so.

4. A factory specialist in the area of major equipment and systems will present sessions on their specific equipment or system, or both.

5. Visual aids, such as slides and video, shall be used during training and made part of the user's permanent files to be used for reference, refresher, and retraining. Provide electronic DVD of training for Owner's use.

6. See Appendix 'A' at the end of this Section for training agenda format.

B. **Training**:

1. All training is to be scheduled (14) days in advance. All scheduling will be coordinated through Director of Buildings and Grounds.

2. At the time of the request, a written training agenda will be submitted, with the request to schedule, to Director of Buildings and Grounds. This allows the District to have the appropriate personnel involved. Contractor is to prepare an attendance verification form (see Appendix 'C' at the end of this section) to be signed by all participants. Architect, in conjunction with Owner's staff, will provide specified training requirements to Contractors at the Pre-Construction Meeting.

3. Certificate of Substantial Completion will not be issued until all training is satisfactorily completed.

4. Training shall be more than a general review of equipment. The goal is to completely prepare personnel for system operation and maintenance.

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5. All training shall be provided during the regular work day, 7:30 a.m. to 3:30 p.m.

6. The Contractor shall provide a certificate indicating date(s) the training was given, hours of training, a list of documentation given to the Owner, names of individuals (including company name and telephone number) providing the training, names of Owner's personnel receiving the training, and a list of the equipment/systems the training was provided for. This certification shall be signed and dated by a representative of the Owner. A copy of all certifications shall be given to the Owner and the Architect/Engineer prior to the closeout of the project.

(Refer to Following Pages for Appendices)

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Appendix 'A'

TYPICAL FIRE SUPPRESSION TRAINING AGENDA

1. Opening Remarks
2. Introduction
3. Description of Fire Suppression Systems
4. Description of Equipment and Systems
   (individual suppliers will discuss their equipment)
5. Start-Up Procedures
6. Operation Procedure
7. Maintenance (list major equipment systems)
   - A. **Routine**
   - B. **Periodic**
   - C. **Service**
   - D. **Lubrication**
   - E. **Overhaul**
   - F. **Factory**
8. Warranties
   - A. **What They Cover**
   - B. **How to Use Them**
9. Spare Parts
10. Tools
    - A. **Normal Tools, Supplies, and Equipment**
    - B. **Special Tools**

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Appendix 'B'

MAINTENANCE AND LUBRICATION SCHEDULE								
UNIT NO.	ROOM NO.	FUNCTION	CONTROL LOCATION	FUSE LOCATION	TYPE OF LUBRICANT	RATE OF LUBRICATION	LUBRICATION DATE	NOTES

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Appendix 'C'

TRAINING DOCUMENTATION

This form documents that the Owner's representative has received training by the Contractor.

Date: _____

Site: _____

Owner's Representative: _____

Signature: _____

Contractor: _____

Contractor Representative: _____

Signature: _____

Training Duration (hours): _____

Description of Training Received: _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

END OF SECTION

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SECTION 21 05 29

HANGERS AND SUPPORTS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories to furnish and install supports, anchors, and seals for equipment, materials, and related work specified elsewhere.

B. **Related Sections:**

1. Section 21 00 00: Fire-Suppression - General Requirements
2. Section 21 10 00: Water-Based Fire-Suppression Systems

PART 2 - PRODUCTS

2.01 SPECIAL APPLICATIONS

A. **Tunnels, Crawl Spaces:** Materials for inserts, rods and hangers in tunnels, crawl spaces shall be of non-ferrous material. Unistrut steel products shall have prime bonderized finish coating. Contractor shall field coat any raw cut edges on steel products with a prime bonderized finish coating.

2.02 PIPING INSERTS AND HANGERS

A. **General Requirements:** Hangers and anchors for piping shall be attached to the building construction. Piping shall not be supported from another pipe.

B. **Hanger Supports and Inserts:** Piping suspended from the building construction above shall be hung from concrete inserts in concrete construction, toggle bolts and rod coupling on prefabricated, reinforced hollow concrete slabs, I-beam clamps or hanger rod, steel washer plate and two nuts on bar joist construction On other types of building construction a field approved type clamp or bracket shall be used. When piping is hung from beams or joist, the attachment shall be made to the top of the beam or joist.

C. **Hangers, Clamps, and Collars:** Piping shall be suspended from inserts, clamps or brackets by means of clevis type or roller type hanger and solid steel rods. Support vertical cast iron and steel pipes at each floor by heavy wrought steel riser clamps or collars. Support vertical copper pipes at each floor by riser clamps with asphalt felt lining under couplings placed in vertical copper piping.

D. **Piping:** Horizontal piping shall be supported at intervals close enough to keep it in alignment and to prevent sagging.

PIPING SUPPORT SPACING			
PIPE DIAMETER	**ROD HANGERS**	**MAXIMUM HORIZONTAL SPACING**	**MAXIMUM VERTICAL SPACING**
Steel Pipe, Schedule 40, 1 Inch and Smaller	3/8 Inch Rod	12 Feet	15 Feet
Steel Pipe, Schedule 40, 1-1/4 Inch to 2 Inch	3/8 Inch Rod	12 Feet	15 Feet
Steel Pipe, Schedule 40, 2-1/2 Inch to 3 Inch	3/8 Inch Rod	15 Feet	15 Feet
Steel Pipe, Schedule 40, 4 to 6 Inch	1/2 Inch Rod	15 Feet	15 Feet
Steel Pipe, Schedule 40, 8 Inch and Larger	1/2 Inch Rod	15 Feet	15 Feet

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E. **Piping**: Vertical piping shall be secured at intervals close enough to keep it in alignment.

1. Neoprene jointed pipe at 5-foot intervals, except where 10-foot lengths are used.

2. Threaded Steel Pipe, every other story height.

3. Steel Pipe with Grooved End Fittings, anchor at each floor level.

PART 3 - EXECUTION

3.01 HANGER INSTALLATION

A. **Hanger Location**: Locate hangers to properly support pipes, relieve strain on pipe and fittings, and allow for ample expansion and contraction. Piping smaller than 4 inch size shall be hung with individual ring hangers where space prevents use of other type hangers.

1. Piping shall not be hung from the roof deck.

B. **Trapeze Hangers**: Groups of pipes at the same elevation and close together may, at Contractor's option, be supported by suitable trapeze hangers suspended from inserts, clamps or brackets by solid steel rods. Provide single pipe roller assemblies as indicated in Part 2 of this Specification.

3.02 BRACKETS, BRACES, AND SUPPORTS

A. **General Requirements**: Furnish and install brackets, braces or reinforcing angles in partitions not sufficient in themselves to support piping or other wall hung equipment included in this Specification. Bolts shall extend through walls, finished on opposite side, or (1) wall of a pipe chase, and shall be not less than 3/8 inch brass bolts with 3 inch cut washer on opposite side of wall.

B. **Fasteners**: Bolt head and washer shall be concealed under wall finish on finished walls. On hollow walls not finished on opposite sides, use toggle bolts. On solid walls, use 3/8 inch brass bolt extending 4 inches into wall secured with molten lead poured around bolt.

C. **Support Racks**: Support tunnel piping on Unistrut, Bee-Line or approved equal, pipe racks assembled as indicated by details on Drawings. Unistrut steel products shall have prime bonderized finish coating. Contractor shall field coat any raw cut edges on steel products with a prime bonderized finish coating.

D. **Pipe Drop Supports**: Brace exposed pipe drops to pumps and other equipment with angle iron framework to relieve strain on flexible connectors or equipment and anchor piping to eliminate movement.

END OF SECTION

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SECTION 21 05 55

PENETRATION SEALANTS FOR FIRE-SUPPRESSION

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories required to furnish and install through-penetration firestop systems at wall and floor openings.

B. **Related Sections:**

1. Section 21 00 00: Fire-Suppression - General Requirements
2. Section 21 10 00: Water-Based Fire-Suppression Systems

1.02 REFERENCES

A. **General:** The following references refer to the latest version of the standards listed.

B. **ASTM International:**

1. ASTM E84, Surface Burning Characteristics of Building Materials
2. ASTM E814, Fire Tests of Through-Penetration Firestops

C. **Underwriters' Laboratories, Inc. (UL):**

1. UL 1479, Fire Tests of Through-Penetrations Firestops
2. UL Building Materials Directory, Through-Penetration Firestop Systems (XHEZ), and Fill, Void or Cavity Materials (XHHW)

1.03 SUBMITTALS

A. **Instructions:** Submit manufacturer's instructions for applying sealant.

B. **Certification:**

1. Submit manufacturer's certifications that materials meet or exceed specified requirements.

2. Submit documentation of manufacturer's acceptance of applicator.

3. Provide certification stating that sealant has been completed in full accordance with requirements to provide necessary fire-resistance ratings.

4. Provide an electronic set (PDF) of certified test reports of:

   a. Fire test reports of sealant application to substrate materials shall be similar to Project conditions.

   b. Reports from reputable independent testing agencies of product proposed for use, indicating conformance with ASTM E814.

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1.04 QUALITY ASSURANCE

A. **Qualifications:** Applicator shall be acceptable to sealant manufacturer.

B. **Regulatory Requirements:**

1. State Building Code Division

2. Local Codes and Ordinances

3. Local Authority having jurisdiction

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Bio-Fireshield, Inc., Concord, MA
2. Carborundum Company, Niagara Falls, NY
3. Dow Corning Corporation, Midland, MI
4. General Electric Company, Silicone Products Division, Waterford, NY
5. Hilti-Ciba-Geigy, Tulsa, OK
6. Metalines, Ind., Oklahoma City, OK
7. 3M Company, St. Paul, MN
8. Nelson Electric, a Unit of General Signal Corporation, Tulsa, OK
9. Tremco, Inc., Beachwood, OH
10. Rectorseal Corp., Houston, TX

2.02 MATERIALS

A. **Description:** Penetration sealant shall be a 1-component ceramic fiber-based putty fill, void or cavity material or 3M fire barrier caulk, putty strip, and sheet forms.

B. **Applications:** Flame Spread/Smoke Contribution shall be 0/0 in accordance with ASTM E84. UL rated material classified for use in Through-Penetration Firestop Systems shall be used for, but not limited to, the following:

1. Metal Pipe

PART 3 - EXECUTION

3.01 EXAMINATION

A. **Verification of Conditions:**

1. Confirm compatibility of surfaces to receive sealant materials.

2. Verify that openings are sound, clean, dry, and ready to receive application of sealants.

3. Verify that penetration elements are securely fixed and properly located, with a minimum of space between penetrations and surfaces of openings.

4. Beginning of installation means acceptance of existing conditions.

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3.02 PREPARATION

A. **Damage:** Protect adjacent surfaces and equipment from damage.

B. **Cleaning:** Clean contact surfaces of dirt, dust, grease, oil, loose material, or other matter which may affect bond of sealant.

1. Remove incompatible materials which affect bond by scraping, brushing, scrubbing, or sandblasting.

3.03 MOCK-UP

A. **General Requirements:** Apply (1) seal on representative substrates on-site for each fire rating required at each type of wall and floor construction. Confirm requirements of fire ratings.

1. Application shall be in accordance with Project requirements as to thickness and density to achieve fire rating.

B. **Acceptance:** Product and application shall be approved by governing authorities prior to continuing with the Work.

1. Approved mock-up may remain as part of the completed Work.

3.04 APPLICATION

A. **Instructions:** Apply sealant in strict accordance with manufacturer's instructions.

B. **Rating:** Apply sealant in sufficient thickness to achieve required rating.

C. **Packing:** Pack material solidly around penetrations, fill openings to a depth as required by manufacturer's UL listing. Minimum shall be in accordance with 1, 2, and 4 hour fire rating as required.

3.05 FIELD QUALITY CONTROL

A. **Inspection:** Perform inspection to verify that Work is in accordance with requirements.

1. Correct unacceptable work and provide further inspection to verify that Work meets requirements.

3.06 CLEANING

A. **Material:** Remove excess material, droppings, and debris.

B. **Sealant:** Remove sealant from materials and surfaces not specifically required to be sealed.

3.07 PROTECTION

A. **General Requirements:** Protect applied sealant from damage.

END OF SECTION

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SECTION 21 10 00

WATER-BASED FIRE-SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. **General Requirements:**

1. Drawings show location and areas that are to be remodeled. Contractor shall install, remove, or relocate all pipe, fittings, heads, and equipment as required for a complete and approved job.

2. Contractor shall submit an electronic set (PDF) of Drawings, hydraulic calculations, and manufacturer's data sheets to the Engineer after approval by State or local authorities, or as requested.

3. Contractor shall comply with all local and State codes.

4. Contractor shall visit the site to become thoroughly acquainted with existing conditions of site and services.

5. Contractor shall coordinate work with other trades to ensure proper sequencing of work without delaying or impairing other trades in their performance of work.

6. Contractor shall verify type of hazard to be sprinklered and install a system as required for the alterations.

B. **Related Sections:**

1.	Section 21 00 00:	Fire-Suppression - General Requirements
2.	Section 21 05 29:	Hangers and Supports for Fire-Suppression Piping and Equipment
3.	Section 21 05 55:	Penetration Sealants for Fire-Suppression

PART 2 - PRODUCTS

2.01 WET PIPE SPRINKLER SYSTEM

A. **General:**

1. New sprinkler work shall be guaranteed by the Contractor for a period of (1) year.

2. Contractor shall provide spare sprinkler heads in accordance with NFPA 13.

3. Sprinkler heads shall match existing head type and manufacturer.

4. Pipe shall be a minimum wall thickness of Schedule 40 pipe.

   a. Where approved by NFPA, State Fire Marshal, and local authorities, Schedule 10 pipe may be used for main piping only.

5. Fittings shall be 125-pound cast iron screwed as manufactured by Victaulic, Gruvlok, or approved equal.

PART 3 - EXECUTION

Not Used

END OF SECTION

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PLUMBING - GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Work included under this division shall consist of furnishing labor and materials necessary for the installation of the work called for under the Mechanical Contract as listed in the Instruction to Bidders, as specified, and as shown on Drawings to provide a complete, operable and approved system.

1. Job Progress: Contractor shall provide sufficient workers and materials to keep pace with the construction schedule. Contractor shall place orders for equipment such that job progress is not slowed due to late delivery and shall confirm delivery dates with suppliers.

2. Coordination: Contractor shall coordinate trades to install systems in the space provided within the structure. Where required, Contractor shall remove and reinstall existing work to allow for a congruous installation. Install systems and materials for ease of maintenance. Equipment arrangements shall provide at least the minimum clearances as recommended by equipment manufacturer to facilitate proper maintenance and servicing of system.

    a. Deviations in minimum clearance requirements shall be permitted only upon prior written authorization from the Architect/Engineer.

B. **Related Sections:**

1. Section 01 11 00: Summary of Work
2. Section 01 23 00: Alternates
3. Section 01 33 00: Submittals
4. Section 01 61 00: Common Product Requirements
5. Section 01 73 29: Cutting and Patching
6. Section 01 77 00: Closeout Procedures

C. **Drawings Use and Interpretation:**

1. The Drawings are diagrammatic and indicate the general arrangement of systems and equipment, unless indicated otherwise by dimensions or Detail Drawings. For exact locations of building elements, refer to dimensioned Architectural/Structural Drawings; however, field measurements take precedence over Dimensioned Drawings. The installation of all systems and equipment is subject to clarification as indicated in Division 1, GENERAL REQUIREMENTS.

2. Piping plans are intended to show size, capacity, approximate location, direction, and general relationship of one work phase to another, but not the exact detail or arrangement.

3. Generally, layout pipelines requiring drainage first, followed by large pipe mains, ductwork, and electrical conduit. Follow this procedure for an orderly installation, but not to establish precedence of one trade over another.

4. Equipment outlines shown on Detail Drawings or dimensions indicated anywhere on the Drawings are limiting dimensions. Equipment exceeding approximate dimensions indicated by equipment outlines on Detail Drawings and any equipment or arrangements that reduce indicated clearances or exceed specific equipment dimensions may not be used.

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D. **CADD Drawings:**

1. After award of Contract, Contractor(s) may request electronic copies of the CADD Drawings.

2. Request for copies of the CADD Drawings shall be in writing and shall clearly indicate the specific sheets of the Drawings which are being ordered.

3. The following pricing shall apply:

a. $100.00 Per Sheet for Unit Information (i.e. Ventilation, Plumbing and Piping).

b. $100.00 Per Reference Plan / Building Plan per Floor.

1.02 REFERENCES

A. **American National Standard Institute (ANSI):**

1. ANSI B31.1, Pressure Piping - Power Piping

B. **American Society of Mechanical Engineers (ASME):**

1. Boiler and Pressure Vessel Code: Section IX, Welding and Brazing Qualifications

C. **American Society of Sanitary Engineering (ASSE)**

D. **ASTM International:**

1. ASTM R84-81, Surface Burning Characteristics of Building Materials

E. **American Water Works Association (AWWA)**

F. **Cast Iron Soil Pipe Institute (CISPI)**

G. **Manufacturer's Standardization Society (MSS of the Valve and Fittings Industry, Inc.):**

1. MSS SP-58-1975, Pipe Hangers and Supports Materials, Design, and Manufacture
2. MSS SP-69-1976, Pipe Hangers and Supports Selection and Application

H. **National Electrical Manufacturers Association (NEMA)**

I. **Plastic Pipe Institute (PPI)**

J. **Steel Tank Institute (STI)**

K. **Underwriters Laboratories (UL)**

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1.03 DESIGN INTENT

A. **Description of Systems:**

1. Plumbing Systems:

a. Piping Materials:

1) Copper Water Mains and Branches.

2) PVC Piping for Sanitary and Storm Below Ground.

3) No-Hub Piping for Sanitary and Storm Above Ground.

b. Domestic hot water is supplied to the building at 120 degrees F.

1) A small circulation line (RHW) returns a portion of the flow to maintain the water temperature in the supply pipe.

1.04 EXISTING SYSTEMS, EQUIPMENT, AND MATERIAL

A. **Hazardous Materials:** Under a previous contract, asbestos-bearing materials have been removed or encapsulated. If asbestos-bearing materials, mercury-containing devices (such as thermostats and pneumatic-electric switches) or other hazardous materials are encountered, do not proceed with work in that location, but immediately inform the Owner so appropriate action can be taken.

B. **Remodeling:** Where relocation of existing equipment and piping systems and materials is necessary in areas providing uninterruptible services, schedule the work for minimal down time during a slack period, if possible. Assign an adequate crew to accomplish the job in least possible time. Prefabricate and install interconnecting portions of these systems prior to shut-down for final connections.

1. Locate existing piping and make connection where required or where shown on the Drawings. Do not cut into existing services without verifying with the Owner that the pipe involved is the desired service. In any area where work performed under Division 22 is the only work involved, restore the area to its original condition upon completion of work.

2. Maintain all existing services and equipment unless otherwise shown on the Drawings.

3. Perform work that interrupts any service (this includes cutting into existing lines for new connections) at times (usually night) to cause the least interference to the normal operation of the building. Anticipate scheduling work at periods which will result in additional construction cost, such as nights and weekends, and include cost in the bid.

4. Inform the building engineering staff in advance of any shut-off that will occur and give an estimate of duration. Only after the engineering staff is fully informed and has agreed to the schedule of shut-offs, can the work then proceed accordingly.

5. All fixtures, piping, and other valuable equipment shall remain property of the Owner, except where noted otherwise, and stored on-site where directed.

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C. **Connections**: Contractor shall field verify and inspect existing buildings for connections to existing systems, equipment, and materials designated on Drawings or in Specifications to be used.

1. Existing piping that is disconnected and not reused shall be capped-leak tight below the floor, within the wall, or above the ceiling.

2. Requests for additional compensation will not be considered when such occurrence is the result of existing conditions.

1.05 SUBMITTALS

A. **General Requirements**: Provide submittals in accordance with Section 01 33 00.

B. **Operating Characteristics**: Submittals shall list actual proposed capacities of equipment submitted. Contractor shall indicate actual operating characteristics of proposed equipment at specified design conditions in the submittal.

C. **Review**: Review of Shop Drawings and other submittals will be general in nature and shall not be considered:

1. As permitting any departure from Contract requirements.

2. As relieving Contractor of responsibility for errors, including details, quantities, dimensions, and materials.

3. Contractor is responsible for reviewing all information in Shop Drawings related to the mechanical systems. Information includes, but is not limited to, the following: size, dimensions, electrical power requirements, horsepower, CFM, GPM, BTU, sound, system operating steam and/or gas pressure, pressure drops (water and air), and tonnage.

4. The Contractor shall highlight all differences between that which is being submitted and that which was specified.

D. **Samples**: Provide samples of material or equipment proposed to be furnished, if requested. Samples shall become the property of the Architect/Engineer and will be returned only when accompanied by a written request to do so.

E. **Record Drawings**: Refer to requirements as indicated in Section 01 77 00.

1. Record Drawings shall be provided in a hard copy and an electronic copy (PDF format).

F. **Compatibility of Equipment**: Contractor shall have full responsibility of component parts of the mechanical system to ensure that new equipment, integrated with existing equipment and systems, shall perform and operate in accordance with requirements of the Specifications without excessive or unusual service or maintenance requirements.

1. Should damage be sustained to existing fixtures, materials or equipment to be reused, relocated or to remain, the same shall be replaced with new material or equipment of equal or better quality as the Architect/Engineer directs.

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2. It shall be the Contractor's responsibility to determine that changes in physical dimensions, access for maintenance, service line connections, structural supports, and vibration devices for substitute (approved equal) equipment are acceptable in the space provided for equipment and that performance characteristics are at least equal to base specification for equipment utilized from the substitutes (approved equals) listed.

3. Increased costs to provide additions or revisions required by acceptable manufacturers not used as basis of design and substitute (approved equal) manufacturers shall be the sole responsibility of this Contractor. Examples of additions or revision shall be as follows, but are not inclusive of all items:

   a. Electrical Service Connections Revisions
   b. Additional Equipment
   c. Wall and Room Layout Revisions
   d. Structural Support Revisions
   e. Screen Wall Revisions
   f. Plumbing Connection Revisions

1.06 QUALITY ASSURANCE

A. **Qualifications:** Where equipment is specified by manufacturer, brand name or catalog number, this shall establish the standard of quality and style of the product to be provided under the Contract.

1. Where (2) or more units of the same kind of equipment are required, they shall be products of a single manufacturer. Mixing and matching of various manufacturer's like or similar components shall not be permitted.

B. **Regulatory Requirements:**

1. State Building Code

2. National Electric Code

3. Plumbing Code

4. Local Codes and Ordinances

1.07 WARRANTY

A. **General Requirements:** Equipment furnished under this Contract shall have a 1-year warranty on parts and labor beginning at the date of Substantial Completion, unless a longer period is specified in the equipment specification section.

1.08 START-UP AND OPERATING REQUIREMENTS

A. **General Requirements:** Provide unit start-up by factory trained and authorized personnel for all Central Plumbing Equipment.

1. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, building is clean, filters are in place, bearings are lubricated (if applicable), condensate is properly trapped, piping connections are verified and leak-tested, belts are aligned and tensioned, all shipping braces are removed, bearing set screws are torqued, and fan has been test run under observation.

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PART 2 - PRODUCTS

2.01 WALL, FLOOR, AND CEILING OPENINGS

A. **General Requirements:** This Contractor shall be responsible for locating chases and openings required for work in the general construction of the building.

B. **Chases and Openings:** Applicable Contractor shall be required to leave chases and openings in walls, floors, ceilings, and partitions where shown on Drawings or otherwise necessary to receive mechanical work.

2.02 SLEEVES

A. **General Requirements:** Provide sleeves in conjunction with pipes passing through concrete or masonry walls, partitions, and slabs. Provide sleeves in mechanical equipment rooms and chases to prevent water flooding from floor to floor, in addition to separating piping from building structure.

1. Sleeves shall extend through full thickness of walls and slabs and shall be at least (2) pipe diameters larger than the pipe passing through. Where pipe with covering is installed, a minimum of 1/4 inch shall be provided between outside of pipe covering and inside surface of sleeve.

2. Core-drilled holes through solid masonry, concrete beams, or filled core concrete block walls do not require sleeves.

3. Where pipes pass through existing walls or floors, holes shall be core-drilled.

B. **Pipe Sleeves:**

1. Exterior Walls: Sleeves shall be standard weight steel pipe. Install sleeves in exterior walls and floors below grade with approved caulking between sleeves and piping to make wall waterproof. Plastic sleeves shall not be used.

2. Floors: Sleeves shall be standard weight steel pipe. Vertical pipe sleeves through floors shall have space between pipe and sleeve packed with an approved fire stop material flush with top of sleeve to make a watertight and fire rated joint.

3. Interior Sleeves: Sleeves shall be standard weight steel pipe. Piping through walls of adjacent rooms shall have soundproof packing (closed cell rod and sound caulking) in non-rated walls and an approved fire stop material in fire rated walls.

4. Fire Rated Wall and Floor Openings: Piping passing through fire rated walls and floors shall be provided as a UL classified pipe and pipe sleeve assembly. Pipe and pipe sleeve assembly shall meet or exceed fire rating of wall and floor which the pipe passes through.

   a. Refer to Section 22 05 55, Penetration Sealants.

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PART 3 - EXECUTION

3.01 EXAMINATION

A. **Verification of Conditions:**

1. On-Site Review: Contractor shall visit site to become thoroughly acquainted with existing conditions of site and services.

2. Existing Active Services: When encountered in Work, Contractor shall protect, brace or support existing active sewers, water, gas, or other services, where required, for proper execution of Work.

   a. If existing active services not indicated on Drawings are encountered, Contractor shall relocate and brace these services at no additional cost to Owner.

3. Inactive Services: If encountered in Work, Contractor, as appropriate, shall cap or plug inactive pipes at no additional cost to Owner.

4. Responsibility: Liability for repairs or replacement of damaged or defective materials, including, but not limited to, property damage resulting from negligence or other causes, shall be the Contractor's sole responsibility until work has been accepted by Architect/ Engineer and Owner.

3.02 PREPARATION

A. **Protection:** After delivery, and before and after installation, equipment shall be protected against theft, injury or damage.

1. Contractor shall protect plumbing fixtures and other equipment, and all baked enamel or glazed surfaces, from damage by covering or coating as recommended in Bulletin, "Handling and Care of Enameled Cast Iron Plumbing Fixtures," issued by Plumbing Fixture Manufacturers Association or by other methods approved by Architect/Engineer.

2. Coat polished or plate metal parts with Vaseline immediately after installation. Protect equipment outlets, pipe, and conduit openings with temporary plugs, caps or burlap as required to prevent filling with construction dirt.

3.03 EXCAVATION AND BACKFILL

A. **Excavation:** Contractor shall perform excavation to required depth for installation of work indicated or specified.

1. Excavated material not required or not suitable for backfilling shall be removed from site.

2. Protect excavation by grading and pumping to keep space clear of water during construction.

3. Provide shoring and sheeting as necessary for protection of work and safety of personnel. Protect bottom of excavation from frost.

4. Excavation in rock shall be 8 inches below invert of pipe to be installed and shall be backfilled to a depth of 8 inches with clean, sharp sand before pipe is laid in trenches.

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5. Excavation terminating in unstable or organic material at pipe invert elevation shall be continued to 2 foot 6 inches below pipe invert elevation and backfilled with pit run gravel to pipe invert.

   a. Soil boring reports are available for inspection at Architect's office.

6. Pipe installation in backfilled areas shall not occur until backfill is 2 feet above pipe invert, at which time backfill shall be excavated to proper depth, pipe installed, and backfill replaced as specified.

B. **Backfilling Under Floors and Slabs:** Backfill areas below concrete slabs-on-grade in horizontal layers not to exceed 8 inches in depth and compact with approved equipment until dry density is not less than 95 percent of Standard Proctor Density.

1. Backfill material shall be pit run gravel or coarse sand, free of rubbish, compacted and leveled to receive slab. If natural earth is of similar structure with same material as specified above, no additional material will be required.

   a. Fill to raise subgrades to required elevation shall be accomplished as specified above.

2. Materials and methods of compaction shall be approved by Architect/Engineer before start of work.

3. Areas not below concrete or asphalt slabs and footings shall be backfilled with suitable excavated material, free of debris and rubbish.

4. Contractor shall pay costs for testing of compacted backfill by an approved testing laboratory when tests are requested by Architect/Engineer.

C. **Backfilling Outside:** Backfill excavations below finished grades with materials similar to that removed in excavation, free from rubbish or other unsuitable material. Compact with approved equipment until dry density is not less than 95 percent of Standard Proctor Density.

1. Backfilling shall be done to finished grades indicated on Drawings. If no finished grading is done in excavated areas, Contractor shall backfill to existing grades and restore surface to original condition.

2. Compaction over ditches less than 3 feet in width and around walls and columns shall be done by the use of mechanical hand compactors.

3. Contractor shall pay costs for testing of compacted backfill by an approved testing laboratory when tests are requested by Architect/Engineer.

D. **Pavement, Curb, and Sidewalk Replacement:** Contractor shall be responsible for the replacement of existing street pavement, curbs, and sidewalks removed or damaged by Contractor or related Subcontractors, unless such pavement, curbs, and sidewalks are to be reconstructed under the General Contract.

1. Make necessary arrangements to perform such repairs and pay incurred costs in connection with said repairs, including amount in Bid.

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3.04 CUTTING AND PATCHING

A. **General Requirements**: Cutting and patching shall be held to practical minimum consistent with good construction practice by properly locating and leaving sleeves and boxes, or notifying applicable Contractor of openings, where required, as construction progresses.

1. Necessary cutting and patching of walls, floors, partitions, and ceilings, as required for the proper installation of work under this Contract, shall be the sole responsibility of this Contractor. Perform cutting and patching in such a manner as to leave no visible trace and to return the area affected to the condition of undisturbed work using the same material as presently installed. Cutting and patching shall be performed by workers experienced, skilled, and licensed for the particular type of work involved. Inferior work will not be accepted.

2. This Contractor is responsible for patching all holes and openings left in existing floors, walls, ceilings, and roofs where any mechanical equipment (such as pipe or other mechanical component) has been removed unless noted otherwise on Drawings. Patching shall be performed by workers experienced, skilled, and licensed for the particular type of work involved. Inferior work will not be accepted.

B. **Pavements:** Cutting of pavements shall be accomplished by saw cutting a minimum of 1 1/2 inches deep prior to jack hammering. Contractor shall bore below pavement where indicated on Drawings or where required by Architect/Engineer.

C. **Existing Conditions:** Patch pavements to match existing conditions. Labor and materials required to replace and rebuild parts cut or injured shall be furnished and installed by this Contractor.

3.05 INSTALLATION

A. **Connection to Equipment Specified:** Provide material and labor required to connect to the mechanical system of fixtures and equipment having mechanical connections and which are specified in other sections or divisions of the Specifications or furnished by Owner.

1. Provide piping supply connections with shut-off valves.

2. Drainage connections shall be properly trapped and vented.

B. **Floor, Wall, and Ceiling Plates:** Where uncovered exposed pipes pass through floors, walls or ceilings in finished rooms and inside casework, fit with approved type chrome plated metal plate.

1. Plastic escutcheon plates shall not be permitted.

C. **Painting Mechanical Systems in Unfinished Rooms (Mechanical Rooms, Boilers Rooms, Chiller Rooms, Etc.):** Exposed supporting iron and steel work, bare pipe, fittings, hangers, and supports shall be wire brushed, washed with mineral spirits to remove dirt and grease, and painted with (1) coat of metal primer followed by (2) finish coats of battleship gray paint.

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D. **Chlorination of Domestic Water Lines (New and Existing):** Clean all new domestic water system, as well as that portion of existing domestic water system necessary to ensure that the entire domestic water system in building is disinfected in strict accordance with governing codes and State Health Department Requirements. Flush entire system clean in compliance with the following:

1. Piping system shall be flushed with clean, potable water until no dirty water appears at the points of outlet.

2. System, or part thereof, shall be filled with a water-chlorine solution containing at least (50) parts per million of chlorine, and the system, or part thereof, shall be valved off and allowed to stand for (24) hours.

3. System, or part thereof, shall be filled with a water-chlorine solution containing at least (200) parts per million of chlorine and allowed to stand for (3) hours.

4. Following allowed standing time, system shall be flushed with clean potable water until no chlorine remains in the water coming from the system.

5. Contractor shall provide written certification to Architect/Engineer that chlorination and flushing of domestic water system have been completed.

E. **Plumbing Equipment Mock-Up Requirements:** This Contractor shall assist and supervise the completion of a mock-up of each piece of plumbing equipment for which there is a Detail in the Mechanical Construction Documents. Provide additional mock-up for fire stop material as indicated in Section 22 05 55.

1. When approved, mock-ups may remain as part of the final installation. Contractor shall coordinate, with the Mechanical Engineer, the installation of the mechanical equipment as a standard of quality that is expected.

2. Before any additional installation work is started in other areas of the building, the Owner and the Architect/Engineer shall approve the mock-up. The Contractor shall obtain approval of each mock-up. Provide a 3-day notice to the Mechanical Engineer to schedule approval of mock-up.

F. **Lubrication:** After systems and equipment have been installed and just prior to building acceptance, properly lubricate motors and equipment installed for this Project in accordance with manufacturer's recommendations.

3.06 TESTS

A. **Plumbing:**

1. Defects: Contractor shall be responsible for defects which develop in the systems caused by faulty workmanship, material or equipment, and shall replace any such faulty workmanship, material or equipment during a period of (1) year from date of final acceptance. Acceptance of the work shall not waive the guarantee.

2. Approval: Inspect and test plumbing work for approval by Architect/Engineer or a designated representative.

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3. Tests: Tests shall be made in Architect/Engineer's presence or a designated representative. Tests shall be made, at Contractor's expense, and a certification furnished to the Architect/Engineer, stating that satisfactory tests have been made.

4. Piping: Tests of piping systems, except final test of complete systems, shall be made before piping is covered or connected to fixtures and equipment. Tests required shall not be less than that which is specified in the following paragraphs, unless designated otherwise in specific sections.

   a. Sanitary sewer, waste and vent piping, and storm sewer inside the building shall be tested with air at 5 psi gauge pressure, and shall hold this pressure for (30) minutes without addition of more air.

   b. Domestic water piping shall be tested with water at a pressure of 150 psi gauge and shall hold this pressure for (1) hour without leaks or additional water.

3.07 CLEANING

A. **Housekeeping, Cleaning and Storage**: Remove from the building and site, scrap material, temporary building, packaging material, miscellaneous debris, and dirt on a regular schedule, or as required, and in accordance with Architect/Engineer's direction, to maintain building in a reasonably clean, workable condition during construction.

1. Cutting oil and steel shavings shall be caught in a suitable container to ensure final finish material in building will not be marred or damaged.

2. Upon completion of work and before final inspection, Contractor shall remove plaster, paint, rust, stickers, and shipping tags from installed equipment.

   a. Clean foreign matter from installed equipment and remove dirt and debris, in connection with work, from building.

3.08 MECHANICAL LIST OF CONSTRUCTION CLOSEOUT DOCUMENTS

A. **Description**: Contractor and its Subcontractors should proceed immediately to fully complete the work as listed in Appendix 'A'. Contractor responsible shall initial and date the "Contractor Completed" column after each item as it is completed and forward a copy of the fully completed punch list to the Engineer for final approval.

(Refer to Following Page for Appendix)

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Appendix 'A'

Section	Document Description	Contractor Date Comp./By	ATS&R Approved
22 00 00	Plumbing Record Drawings.	____/____	____
22 00 00	Provide documentation that chlorination and flushing of domestic water system has been completed.	____/____	____
22 00 00	Provide certification stating that satisfactory tests have been made on plumbing piping.	____/____	____
22 01 00	Plumbing operation and maintenance manuals.	____/____	____
22 01 00	Maintenance and lubrication schedule (plumbing).	____/____	____
22 01 00	Document instruction on plumbing systems.	____/____	____
22 05 23	Valve tag schedule (plumbing).	____/____	____
22 05 23	Provide a typewritten list identifying all numbered valves and submit with Operation and Maintenance Manual.	____/____	____
22 11 00	Document testing for lead in water before and after installation.	____/____	____

END OF SECTION

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SECTION 22 01 00

OPERATION AND MAINTENANCE OF PLUMBING

PART 1 - GENERAL

1.01 OPERATION AND MAINTENANCE (O&M) MANUALS

A. **General Requirements:** This Section is in addition to Division 1, O&M Manual requirements.

B. **Section Submittal:** O&M Manuals shall be submitted in paper and electronic formats. Contractor shall complete and submit (3) copies of each O&M Manual section (main tab) within (30) days of the respective submittal acceptance. Manuals will be reviewed for compliance and acceptability by Architect/Engineer.

1. Electronic format shall be provided on CD in format acceptable to Owner.

C. **Complete Submittal:** (60) days prior to the originally scheduled Substantial Completion Date, Contractor shall compile individual O&M Manual sections and submit (3) complete copies to Architect/Engineer. Contractor shall compile O&M Manuals for every piece of equipment and building operating system in accordance with the following requirements:

1. Format: 8 1/2 by 11 inch loose leaf binders. Each binder shall be clearly labeled on the spine. Use as many as required. Do not overload binders. Use dividers with permanently marked tabs of card stock separating each section and subsection. Tab labels must be easily readable and not handwritten.

2. Each binder shall be composed of:

a. Title Page

b. Table of Contents

c. Main Tab for Each Specifications Section

d. Sub-Tab for Each Piece of Major Equipment (or group, if small or numerous)

3. Each sub-tab shall be similar to the main tab for the Specification Section, but of a different color. Inside each equipment sub-tab shall be the following sections, in the given order, divided by a double-weight colored sheet labeled with the title of the section.

a. Contractor: Record the name, address, and telephone number of the manufacturer and installing contractor, and the 24-hour number for emergency service for all equipment in this sub-tab, identified by equipment.

b. Submittal and Product Data: Section shall include all approved submittal data, cut sheets, and appropriate Shop Drawings. If a submittal was not required for approval, include descriptive product data.

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c. Operation and Maintenance Instructions: Written manufacturer's data with the model and features of this installation clearly marked and edited to omit reference to products or data not applicable to this installation. This Section shall include data on the following:

1) Installation, start-up, and break-in instructions and reports.

2) All starting, normal shutdown, emergency shutdown, manual operations, seasonal changeover, and normal operating procedures and data, including any special limitations.

3) O&M and installation instructions that were shipped with the unit.

4) Preventive maintenance and service procedures and schedules.

5) Troubleshooting procedures.

6) A parts list, edited to omit reference to items that do not apply to this installation.

7) A list of any special tools required to service or maintain the equipment.

8) Warranty, which clearly lists conditions to be maintained to keep warranty in effect and conditions that would affect the validity of the warranty.

9) Any service contracts issued.

10) A maintenance and lubrication schedule (refer to Appendix 'B' at the end of this Section for a blank form) which includes each motor, function, control location, fuse location, type of lubricant, and rate of lubrication in accordance with manufacturer.

d. Specifications: This Section is comprised of the component or system specification section copied and inserted, including all addenda.

e. System Description: This Section shall include the individual equipment portion of the overall system design documentation narrative. It will contain simplified professionally drawn single line system diagrams on 8 1/2 by 11 inch or 11 by 17 inch sheets, showing all controls, connections, and interfaces.

f. Preventive Maintenance Instructions: This Section shall include condensed, typewritten excerpts from the manufacturer's written instructions for weekly, monthly, quarterly, annual, etc. maintenance. This summary shall be prepared by the responsible Contractor with help from the equipment supplier. It shall be prepared for all installed equipment. This section should include checklists for each task required.

g. Supplemental Data: When manufacturer's standard printed data is not available or the information necessary for a proper understanding and O&M of equipment or systems is missing, supplemental data shall be developed by the responsible Contractor for the equipment. This data shall be written text and simple Schematic Drawings.

h. Include a warranty letter in the O&M Manual, to include the starting date(s) of warranty period(s) (including delayed start warranties and extended warranties) and duration of warranty periods. Warranty date should correspond to Substantial Completion Date established by the Contract Documents.

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1.02 INSTRUCTION

A. **General Requirements:** At completion of the Project, when all systems are operating, the Contractor or its representative shall provide a minimum day(s) instruction period for Owner's personnel on the plumbing equipment.

1. Instruction shall take the form of classroom sessions to introduce the operation, maintenance, and management personnel to the manuals, drawings, and other documents, and aids available to operate and maintain plumbing equipment and systems.

2. Instruction shall provide sufficient information to allow Owner's personnel to understand and operate all equipment and components.

3. Contractor shall coordinate and assist Owner to allow for video taping of on-site training if Owner chooses to do so.

4. A factory specialist in the area of major equipment and systems shall present sessions on their specific equipment or system, or both.

5. Visual aids, such as slides and video, shall be used during training and made part of the user's permanent files to be used for reference, refresher, and retraining. Provide electronic DVD of training for Owner's use.

6. Refer to Appendix 'A' at the end of this Section for training agenda format.

B. **Training:**

1. All training is to be scheduled (14) days in advance. All scheduling shall be coordinated through the Director of Buildings and Grounds.

2. At the time of the request, a written training agenda will be submitted, with the request to schedule, to Director of Buildings and Grounds. This allows the District to have the appropriate personnel involved. Contractor is to prepare an attendance verification form (see Appendix 'C' at the end of this section) to be signed by all participants. Architect in conjunction with Owner's staff will provide specified training requirements to Contractors at the Pre-Construction Meeting.

3. Certificate of Substantial Completion will not be issued until all training is satisfactorily completed.

4. Training shall be more than a general review of equipment. The goal is to completely prepare personnel for system operation and maintenance.

5. All summer/winter change-over methods shall be provided in written form as related to the specific project. This shall be provided at the training session. Until this process is complete.

6. All training shall be provided during regular work hours; 7:30 a.m. to 3:30 p.m.

7. Contractor shall provide a Certificate indicating date(s) training was given, hours of training, a list of documentation given to Owner, the names of individuals (including company name and telephone number) providing the training, the names of Owner's personnel receiving the training, and a list of the equipment/systems the training was provided for. This Certification shall be signed and dated by a representative of the Owner. A copy of all the Certifications shall be given to the Owner and the Architect/Engineer prior to the closeout of the Project.

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(Refer to Following Pages for Appendices A, B and C)
Appendix 'A'
TYPICAL PLUMBING TRAINING AGENDA

1.03 TRAINING AGENDA

A. **Opening Remarks**

B. **Introduction**

C. **Description of Plumbing Systems**

D. **Description of Equipment and Systems (Individual Suppliers Will Discuss Their Equipment)**

E. **Walk-Through of Building**

F. **Start-Up Procedures**

1. Check List
2. Emergency Procedures

G. **Operation Procedure**

1. Occupancy Considerations
2. Manual/Automatic
3. Emergency

H. **Shut Down**

1. Check List
2. Normal
3. Emergency

I. **Maintenance (List Major Equipment Systems)**

1. Routine
2. Periodic
3. Service
4. Lubrication
5. Overhaul
6. Factory

J. **Warranties**

1. What They Cover
2. How To Use Them

K. **Spare Parts**

L. **Tools**

1. Normal Tools, Supplies, and Equipment
2. Special Tools

M. **Hands-on Operation of Plumbing Equipment and Systems**

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Appendix 'B'

MAINTENANCE AND LUBRICATION SCHEDULE								
UNIT NO.	ROOM NO.	FUNCTION	CONTROL LOCATION	FUSE LOCATION	TYPE OF LUBRICANT	RATE OF LUBRICATION	LUBRICATION DATE	NOTES

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Appendix 'C'

TRAINING DOCUMENTATION

This form documents that the Owner's representative has received training by the Contractor.

Date: _____

Site: _____

Owner's Representative: _____

Signature: _____

Contractor: _____

Contractor Representative: _____

Signature: _____

Training Duration (Hours): _____

Description of Training Received: _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

END OF SECTION

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SECTION 22 05 16

EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories necessary to furnish and install expansion fittings and loops applicable to plumbing piping systems.

B. **Related Sections:**

1. Section 22 00 00: Plumbing - General Requirements
2. Section 22 05 29: Hangers and Supports for Plumbing Piping and Equipment
3. Section 22 11 00: Facility Water Distribution

1.02 SUBMITTALS

A. **Shop Drawings:** Submit a portfolio showing piping specialties for approval by Architect/Engineer.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers for Expansion Loops- Plumbing:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Flexicraft
2. Metraflex
3. Flexweld
4. Keflex

2.02 EXPANSION LOOPS- PLUMBING

A. **Expansion Loops - Plumbing Piping:** Expansion loops in hot water and recir piping, 3 inches or larger, shall be Metraflex Metraloop, or approved equal, flexible hose expansion loop and 150 pound ASA bronze, flanges. Expansion loops may be used in lieu of joints where space permits.

1. Provide flexible hose expansion loop(s) as indicated on the contract drawings or as required to accommodate any thermal expansion, contraction or seismic movement of the piping system.

2. Flexible hose expansion loops shall be manufactured complete with two parallel sections of corrugated metal house, compatible braid, 180 deg return bend, with inlet and outlet connections. Field fabricated loops shall not be acceptable.

3. Flexible loops shall be capable of movement in the $\pm X$, $\pm Y$, and $\pm Z$ planes.

4. Flexible hose expansion loops shall impart no thrust loads to system support, anchors or building structure.

5. Corrugated Hose:

a. Stainless Steel, B.1.1 Type 304, B.1.2 Type 321, B.1.3 Type 316, 2.1.1 Bronze

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6. Braid:

   a. 304 Stainless Steel braid shall be used for any Series 300 stainless steel hose.

   b. Bronze braid shall be used for any bronze hose.

7. Fittings Materials of construction and end fitting type shall be consistent with pipe material and equipment/ pipe connection fittings. Copper fittings shall not be attached to stainless steel hose.

8. Flexible hose expansion loops shall have a factory supplied, hanger / support lug located at the bottom of the 180deg return.

9. Flexible hose expansion loop(s) shall be furnished with a plugged FPT to be used for a drain or air release vent.

Loop Size	FPT Size
1" - 6"	3/8"
8" and Larger	1/2"

10. Flexible hose expansion loop(s) shall be rated with an operating pressure in accordance with the table below. The operating pressure shall be based on burst pressure with a 4 to 1 safety factor.

11. Flexible Expansion Loop with Bronze Hose:

Size	Working Pressure at 70° F. Single Braid	Working Pressure at 70° F. Double Braid
1/2"	566 PSI	753 PSI
3/4"	468	622
1"	334	444
1 1/4"	306	407
1 1/2"	297	395
2"	210	279
2 1/2"	194	258
3"	166	221
4"	109	175

PART 3 - EXECUTION

3.01 INSTALLATION

A. **Expansion Loops:** Install expansion loops centered between anchors (every 70 feet of straight pipe), or where called for on Drawings. Loops shall be of size shown. Install and guide per manufacturers' installation instructions and Mechanical Contractors Association of America "Guidelines for Quality Piping Installations".

1. Flexible hose expansion loop return fitting shall be supported to allow movement.

END OF SECTION

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GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories necessary to furnish and install valves indicated on Drawings and specified.

B. **Related Sections:**

1. Section 22 00 00: Plumbing - General Requirements
2. Section 22 01 00: Operation and Maintenance of Plumbing
3. Section 22 11 00: Facility Water Distribution

1.02 REFERENCES

A. **American Society of Testing and Materials (ASTM)**

B. **American Society of Mechanical Engineers (ASME):**

1. ASME B16.34: Valves - Flanged and Soldered End.

1.03 SUBMITTALS

A. **Shop Drawings:** Contractor shall submit a Shop Drawing portfolio showing valves, cocks, and faucets to be used and a schedule of equipment and areas to be served for approval by Architect/Engineer.

B. **Lead Free:** Valves used in domestic water systems shall be labeled to meet the current lead free standards required by state and local codes and ordinances. Shop drawings shall clearly state lead free for plumbing applications. All valve models listed with-in this section for domestic water systems shall be lead free wether specifically stated or not.

1.04 QUALITY ASSURANCE

A. **Regulatory Requirements:**

1. State Building Code

2. Plumbing Code

3. Local Codes and Ordinances

4. Local Authority having jurisdiction

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PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers for Globe Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milwaukee
2. Mueller
3. Watts

B. **Acceptable Manufacturers for Check Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milwaukee
2. Mueller
3. Watts

C. **Acceptable Manufacturers for Non-Slam Check Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milwaukee
2. Mueller
3. Watts

D. **Acceptable Manufacturers for Angle Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milwaukee
2. Mueller
3. Watts

E. **Acceptable Manufacturers for Full Port Ball Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Apollo
2. Milwaukee
3. Mueller
4. Watts

F. **Acceptable Manufacturers for Plug Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milwaukee
2. Mueller
3. Watts

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G. **Acceptable Manufacturers for Butterfly Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milwaukee
2. Mueller
3. Watts

2.02 MATERIALS

1. Globe Valves:

   a. 2 Inches and Smaller:

      1) Milwaukee Model 1502, 125-Pound Soldered Ends

   b. 2 1/2 Inches and Larger:

      1) Milwaukee Model 2981-M, 125-Pound Flanged Ends

2. Check Valves:

   a. 2 Inches and Smaller:

      1) Milwaukee Model 1509, 125-Pound Swing Check Soldered Ends

   b. 2 1/2 Inches and Larger:

      1) Milwaukee Model F-2974A, 125-Pound Swing Check Flanged Ends

3. Angle Valves:

   a. 2 Inches and Smaller:

      1) Milwaukee Model 1504, 125-Pound Soldered Ends

   b. 2 1/2 Inches and Larger:

      1) Stockham Figure G-515, 125-Pound Flanged Ends

4. Full Port Ball Valves:

   a. 2 Inches and Smaller:

      1) Milwaukee Model BA 400, Full Port, 600-Pound W.O.G., Soldered

   b. 2 1/2 Inches Through 6 Inches:

      1) Milwaukee Model F 201CSN2 , Full Port, Class 150, Flanged

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c. 8 Inches Through 12 Inches:

1) Milwaukee Model F 201CSN2, Full Port, Gear Driven, Class 150, Flanged

d. Ball valves in insulated piping shall have 1 1/4-inch extended stems.

B. **Butterfly Valves:** Butterfly valves may be used only in systems where operating temperatures do not exceed 200 degrees F, after obtaining written permission from Architect/Engineer for each specific location. Seat material shall be EPDM. Valve bodies shall be of high grade cast iron with extended neck to accommodate pipe insulation, and shall be of lug body design using cap screws to provide end-of-line service. Discs shall be of aluminum bronze construction with no external fasteners. Stems shall be of 316 stainless steel, 2-piece type, with infinitely adjustable, corrosion resistant throttling handle with memory stop. Valves 2 inches to 6 inches shall have throttling levers; 8 inches and larger shall utilize worm gear operators.

C. **Check Valves:** Check valves in chilled and cooling tower water piping to be Demco, Type K-F, silent non-slam rated for 150-pound service with 316 stainless steel internal operating parts and Teflon bushings.

D. **Drain Valves:** Locate where shown on Drawings and at all low points in system; Milwaukee Model BA-150H with hose thread, cap and chain, 600-pound W.O.G., soldered, in accessible location for easy draining of heating and chilled water system.

E. **Valve Tags:** Valves shall be provided with Seton, Model 250BL, 1 1/2-inch round valve tag with a 36-nickel plated bead chain. Stamp tags with description of equipment, piping or fixtures served and valve numbers. Provide a typewritten list identifying all numbered valves and submit with Operation and Maintenance Manual; refer to Appendix 'A' at end of this Section for sample and blank form. For remodel and addition projects, Contractor shall coordinate valve tagging with Owner's existing tagging procedures and logs.

PART 3 - EXECUTION

3.01 INSTALLATION

A. **General Requirements:** Furnish and install full port ball, globe, and check valves where indicated on Drawings and where necessary for proper control of piping and equipment. Valves shall be same size as pipe in which installed, unless otherwise specified or shown on Drawings.

1. Full port ball valves shall be used where shut-off valves are to be fully open or closed.

2. Globe, full port ball, and angle valves shall be used where flow is to be throttled.

3. Valves on chromium plated piping shall be polished brass finish chromium plated. Compression stops shall be heavy pattern with stuffing box.

4. Valves shall be of (1) manufacturer and shall have name or trademark cast or stamped on valve.

a. Valves shall have packing gland nut, packing and back seating design.

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B. **Accessibility/Operation:**

1. Valves shall be installed to be easily accessible for operation, visual inspection, and preventive maintenance.

2. Unless otherwise noted, valves shall be installed with valve stem in vertical position above piping, except chain-operated valves.

3. Valves with stem above 8 feet from floor in Boiler or Equipment Rooms shall have chain wheel operator and chain with chain guard.

C. **Butterfly and Ball Valve Substitution:**

1. Globe valves, 4 inches and larger, may be replaced with butterfly valves.

2. Globe valves, 3 inches and smaller, may be replaced with ball valves.

(Refer to Following Page for Valve Tag Schedule)

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Appendix 'A'

VALVE TAG SCHEDULE							
VALVE TAG	LOCATION	TYPE	SIZE	FUNCTION	SYSTEM	MATERIAL	REMARKS
VALVE #1	*C119*	*BALL*	*3/4"*	*SHUT-OFF*	*DOMESTIC*	*BRONZE*	*THIS IS AN EXAMPLE.*
VALVE #2	*G138*	*GLOBE*	*2"*	*DRAIN*	*HEATING*	*IRON*	*THIS IS AN EXAMPLE.*

END OF SECTION

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SECTION 22 05 29

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories to furnish and install supports, anchors, and seals for equipment, materials, and related work specified elsewhere.

B. **Related Sections:**

1. Section 22 00 00: Plumbing - General Requirements
2. Section 22 11 00: Facility Water Distribution

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers for Guides:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Metraflex
2. Hyspan
3. Flexweld
4. Keflex
5. Flexicraft
6. Flexonic

2.02 PIPING INSERTS AND HANGERS

A. **General Requirements:** Hangers and anchors for piping shall be attached to the building construction. Piping shall not be supported from another pipe.

B. **Hanger Supports and Inserts:** Piping suspended from the building construction above shall be hung from concrete inserts in concrete construction, toggle bolts and rod coupling on prefabricated, reinforced hollow concrete slabs, I-beam clamps or hanger rod, steel washer plate, and (2) nuts on bar joist construction. On other types of building construction, a field approved type clamp or bracket shall be used. When piping is hung from beams or joist, attachment shall be made to top of beam or joist.

C. **Hangers, Clamps, and Collars:** Piping shall be suspended from inserts, clamps or brackets by means of clevis type or roller type hanger and solid steel rods. Support vertical cast iron and steel pipes at each floor by heavy wrought steel riser clamps or collars. Support vertical copper pipes at each floor by riser clamps with asphalt felt lining under couplings placed in vertical copper piping.

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D. **Piping:** Horizontal piping shall be supported at intervals close enough to keep in alignment and to prevent sagging.

PIPING SUPPORT SPACING***			
PIPE DIAMETER	ROD HANGERS	MAXIMUM HORIZONTAL SPACING	MAXIMUM VERTICAL SPACING
Cast-Iron Pipe, 1 1/2 Inch and Larger *	1/2 Inch Rod	5 Feet	15 Feet
Copper or Copper-Alloy Pipe, 1 1/2 Inch and Smaller	3/8 Inch Rod	6 Feet	10 Feet
Copper or Copper-Alloy Pipe, 2 Inch and Larger	3/8 Inch Rod	10 Feet	10 Feet
Copper or Copper-Alloy Tubing, 1 1/2 Inch and Smaller	3/8 Inch Rod	6 Feet	10 Feet
Copper or Copper-Alloy Tubing, 2 Inch and Larger	3/8 Inch Rod	10 Feet	10 Feet
Cpvc Pipe or Tubing, 1 Inch and Smaller	3/8 Inch Rod	32 Inches	10 Feet **
Cpvc Pipe or Tubing, 1 1/4 Inch and Larger	3/8 Inch Rod	32 Inches	10 Feet **
Polypropylene Pipe	3/8 Inch Rod	32 Inches	10 Feet **
Polyvinylidene Fluoride Pipe	3/8 Inch Rod	32 Inches	10 Feet **
PVC Pipe	3/8 Inch Rod	32 Inches	10 Feet **
Exposed Vertical Plastic Piping	3/8 Inch Rod	—	4 Feet

* WHERE 10-FOOT LENGTHS OF CAST-IRON PIPE ARE USED, 10-FOOT INTERVALS BETWEEN SUPPORTS ARE ACCEPTABLE.
** PROVIDE MID-STORY GUIDE.
*** DOES NOT INCLUDE GAS PIPING.

E. **Piping:** Vertical piping shall be secured at intervals close enough to keep in alignment.

1. Copper Tubing, at each story.

2. Cast-Iron Soil Pipe, at base and at each story height. Neoprene jointed pipe at 5 foot intervals, except where 10 foot lengths are used.

3. Threaded Steel Pipe, at every other story height.

4. Steel Pipe With Grooved End Fittings, anchor at each floor level.

2.03 ANCHORS AND GUIDES

A. **Anchor Fabrication:** Construct anchors using I-beams, channel iron, tees, or angles, or a combination thereof.

1. Tee iron shall be welded to side, top or bottom of pipe. Angle iron diagonal bracing shall be welded or bolted to tee iron and wall or ceiling. Anchors shall be welded or double clamped to pipe.

2. Where a group of pipes are to be anchored, but cannot be secured as above, the pipes shall be anchored to an assembly constructed of I-beams, channels or both, which shall be anchored to the building structure.

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B. **Guides**: Guides shall be fabricated from carbon steel. Housing shall be of 2-piece design, connecting upper and lower housing with (2) bolts or by welding, after spider and pipe have been set in lower half of housing. Lower housing shall have (2) legs for support running the full length of housing. 2-piece spider clamp shall be fastened around pipe (or pipe with insulation) with (2) bolts forming (6) legs which guide pipe inside housing. Legs may be on bottom, side or top of unit for bolting to floor or top of beam, wall or underside of structure.

1. Insulation inside spider clamp shall be hydrous calcium chloride with vapor barrier from entering and exiting pipe continuing through clamp.

2. Unit shall be furnished with a factory baked enamel finish.

PART 3 - EXECUTION

3.01 HANGER INSTALLATION

A. **Hanger Location**: Locate hangers to properly support pipes; relieve strain on pipe and fittings; and allow for ample expansion and contraction. Piping smaller than 4 inch size shall be hung with individual ring hangers where space prevents use of other type hangers.

1. Piping shall not be hung from roof deck.

2. Insulation sheet metal shields shall be placed between insulation and pipe hangers at all hangers.

B. **Domestic Water Piping Support**: Suspend and support domestic water piping as indicated above, except domestic water piping shall be supported over piping insulation saddles as indicated in Section 22 07 00 with no break in insulation vapor barrier.

C. **Anchor Piping in Chases**: Copper piping in pipe chases behind plumbing fixtures shall be anchored to waste and vent piping with angle iron and U-clamps with asphalt felt lining under clamps.

D. **Trapeze Hangers**: Groups of pipes at the same elevation and close together may, at Contractor's option, be supported by suitable trapeze hangers suspended from inserts, clamps or brackets by solid steel rods. Provide single pipe roller assemblies as indicated in Part 2 of this Section.

E. **Hub and Spigot Support**: Support hub and spigot pipe not underground from above hangers at each joint in pipe run.

F. **"Hubless" Pipe Support**: "Hubless" soil pipe runs shall have (2) hangers per joint; (1) on each side of joints.

G. **Plastic Piping Support**: Support plastic piping from above inserts, clamps or brackets with Grinnell Figure 269 adjustable ring hanger on 32 inch centers.

3.02 BRACKETS, BRACES, AND SUPPORTS

A. **General Requirements**: Furnish and install brackets, braces or reinforcing angles in partitions not sufficient in themselves to support piping or plumbing fixtures or other wall hung equipment included in this Specification. Bolts shall extend through walls, finished on opposite side, or (1) wall of a pipe chase, and shall be not less than 3/8 inch brass bolts with 3 inch cut washer on opposite side of wall.

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B. **Fasteners:** Bolt head and washer shall be concealed under wall finish on finished walls. On hollow walls not finished on opposite sides, use toggle bolts. On solid walls, use 3/8 inch brass bolt extending 4 inches into wall secured with molten lead poured around bolt. Secure floor mounted wall closets with 5/16 inch brass bolt with chrome plated cap, nut, and washer.

C. **Support Racks:** Support tunnel piping on Unistrut, B-Line, or approved equal, pipe racks assembled as indicated by details on Drawings. Unistrut steel products shall have prime bonderized finish coating. Contractor shall field coat any raw cut edges on steel products with a prime bonderized finish coating.

D. **Pipe Drop Supports:** Brace exposed pipe drops to pumps and other equipment with angle iron framework to relieve strain on flexible connectors or equipment and anchor piping to eliminate movement.

3.03 INSTALLATION OF ANCHORS AND GUIDES

A. **Anchors:** Install anchors approximately centered in every 70-foot run, blind ends, changes in pipe direction, except when elbow is used to absorb expansion and at major branch connections.

1. An expansion joint or loop or expansion elbow, but not more than one, with appropriate guides, shall be installed between each pair of anchors.

2. If expansion loops are installed in same line with expansion joints, section containing loop shall be isolated from section containing joint by means of an anchor.

B. **Guides:** Install (4) guides, (2) on each side, for each expansion loop or joint. On each side, install (1) pipe guide a maximum of (4) pipe diameters from expansion loop or joint and (1) pipe guide a maximum of (14) diameters from first guide.

END OF SECTION

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IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

Not Used

PART 2 - PRODUCTS

2.01 MECHANICAL IDENTIFICATION

A. All pipe markers (purchased or stenciled) shall conform to ANSI A13.1. Hazardous materials (toxic, extreme temperature or pressure etc.) shall have black letters on yellow background. Low hazard liquids shall have white letters on green background. Low hazard gasses shall have white letters on blue background. Letter sizes shall be at least the following:

O.D. OF PIPE OR INSULATION	SIZE OF LETTERS
UP TO 1-1/4 Inch	1/2 Inch
1-1/4 Inch	3/4 Inch
1-1/4 Inch To 2 Inch	1-1/4 Inch
2-1/2 Inch To 10 Inch	2-1/2 Inch
Over 10 Inches	3-1/2 Inch
PLASTIC TAGS MAY BE USED FOR OUTSIDE DIAMETERS UNDER 3/4"	

B. Acceptable Manufacturers shall be W.H. Brady, Seton, or approved equals.

C. **Plastic Nameplates:** Laminated three-layer phenolic with engraved black, 1/4 inch minimum letters on light contrasting background.

D. **Aluminum Nameplates:** Black enamel background with natural aluminum border and engraved letters furnished with two mounting holes and screws.

E. **Plastic Tags:** Minimum 1 1/2 inch square or round laminated three-layer phenolic with engraved, 1/4 inch minimum black letters on light contrasting background.

F. **Bass Tags:** Brass background with engraved black letters. Tag size minimum 1 1/2 inch square or 1 1/2 inch round.

G. **Plastic Pipe Markers:** Semi-rigid plastic, preformed to fit around pipe or pipe covering; indicating flow direction and fluid conveyed.

H. **Vinyl Pipe Markers:** Colored vinyl with permanent pressure sensitive adhesive backing.

I. **Stencil Painted Pipe Markers:** Use industrial enamel spray paint per ANSI Standard A13.1. Indicate fluid conveyed and flow direction.

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PART 3 - EXECUTION

3.01 IDENTIFICATION AND LABELING

A. **Exposed and Concealed Piping:** Bare and insulated exposed new piping in Boiler Room, Mechanical Rooms, and unfinished rooms, and bare and insulated new piping running in ceilings and soffits shall be identified with labels. Labels shall include a directional arrow 3 inches long by 1/2 inch wide, indicating direction of flow.

1. Labels shall be clearly visible and located at each change in direction of pipe runs, at each valve, on both sides of walls, partitions, and floors that pieces penetrate, at each riser and each leg of each "T" joint, at least once in every room, and at intervals not to exceed 20 feet.

2. Underground pipe markers shall be installed 8 inches to 10 inches below grade, directly above buried pipes.

B. **Pipe Markers:** Contractor shall label the piping as follows:

PIPE SERVICE	LABEL	LETTERING COLOR	BACKGROUND COLOR
Condensate Drain	CD	Black	Yellow
Domestic Cold Water	CW	White	Green
Domestic Hot Water (120°f)	HW	White	Green
Domestic Hot Water (140°f)	HW (140°F)	White	Green
Domestic Hot Water (180°f)	HW (180°F)	White	Green
Domestic Recirculating Hot Water	RHW	White	Green
Natural Gas	G	Black	Yellow
Non-potable Water	NP	White	Green
Rain Water Leader	RWL	White	Green
Sanitary Service	SAN	Black	Yellow
Tempered Water	TW	White	Green
Vent	VENT	White	Green
NOTE: EXPOSED GAS PIPING SHALL BE PAINTED YELLOW.			

C. **Concealed Equipment:**

1. The location of equipment, furnished under this Contract, installed above ceiling shall be identified by placing a clear adhesive label with 1/4 inch lettering on the ceiling grid directly below item identified. Attached a 1/2 inch red adhesive dot next to the equipment label. Identification shall be as follows:

   a. Control Valves (with valve numbers)

   b. Shut-Off Valves (with valve numbers)

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D. **Equipment**:

1. General: Provide engraved plastic laminated signs on or near each major item of mechanical equipment and at all equipment not easily identifiable such as controls, relays, gauges, etc.; and all equipment in an area remote from its function, etc.; shall have tags or nameplates listing name, function, and drawing symbol, fasten tags with stainless steel self-tapping screws or permanently bonding cement.

2. Schedule: Provide signs for the following equipment. Signs shall be a minimum of 1 1/2 inches high with 3/4 inch high lettering:

   a. Pumps, Tanks, Pressure Vessels

   b. Compressors

   c. Safety Equipment

   d. Meters, Variable Speed Drives

E. **Miscellaneous**:

1. Provide ceiling markers at all hydronic and plumbing valves, accessories, water hammer arresters, etc. that are located above ceilings. Markers shall indicate number and type of valve referenced on valve directory.

2. All identification and labeling shall be completed before above ceiling inspections will take place.

END OF SECTION

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SECTION 22 05 54

ACCESS DOORS FOR PLUMBING

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:**

1. Furnish wall and ceiling access doors indicated on Drawings and as indicated in Part 3 of this Specification.

B. **Related Sections:**

1. Section 22 00 00: Plumbing - General Requirements
2. Section 22 11 00: Facility Water Distribution

1.02 SUBMITTALS

A. **General Requirements:** Provide submittals in accordance with Section 01 33 00.

B. **Product Data:** Submit manufacturer's technical data and installation instructions, including setting drawings, templates, instructions, and directions for installation of anchorage devices.

C. **Shop Drawings:** Submit a Shop Drawing portfolio showing access panels to be used and a schedule of equipment and areas to be served for approval by Architect/Engineer. Include details, elevations, anchorage, and accessory items.

1.03 QUALITY ASSURANCE

A. **Fire Resistance Ratings:** Wherever a fire resistance classification is indicated, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in Underwriters' Laboratories, Inc., "Classified Building Materials Index" for rating shown.

B. **Identification of Fire Rating:** Provide Underwriters' Laboratories label on each fire rated access door.

C. **Size Variations:** Obtain Architect's acceptance of manufacturer's standard size units which may vary slightly from sizes indicated on Drawings.

D. **Coordination:** Furnish inserts and anchoring devices which shall be built into other work for installation of access doors. Coordinate delivery with other work to avoid delay.

PART 2 - PRODUCTS

2.01 FLUSH PANEL WALL ACCESS DOOR

A. **Acceptable Manufacturers:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milcor Limited Partnership, Lima, Ohio; "Style M"

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B. **Fabrication:**

1. Sizes: 24 inches by 24 inches for gypsum wall board or plaster surfaces and 16 inches by 16 inches for masonry surfaces.

2. Frame Material: 16 gauge steel.

3. Door Panel Material and Construction: 20 gauge steel.

4. Finish: Chemically bonded prime coat of baked enamel over a protective phosphate coating on the steel.

5. Hinge: Concealed spring hinges or continuous piano hinge with removable pins.

6. Locking Device: Key operated cylinder lock with 2 keys. Coordinate with Owner to insure that all access panels for Project operate by same key.

7. Anchors: Provide appropriate anchors for adjacent construction.

2.02 FLUSH PANEL FIRE RATED WALL ACCESS DOOR

A. **Acceptable Manufacturers:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milcor Limited Partnership, Lima, Ohio; "Style UFR"

B. **Fire Rating:** Access door shall carry Underwriters' Laboratories 1 1/2 hour "B" Label rating.

C. **Fabrication:**

1. Sizes: 24 inches by 24 inches for gypsum wall board or plaster surfaces and 16 inches by 16 inches for masonry surfaces.

2. Frame Material: 16 gauge steel.

3. Door Panel Material and Construction: 20 gauge steel.

4. Finish: Chemically bonded prime coat of baked enamel over a protective phosphate coating on the steel.

5. Hinge: Concealed spring hinges or continuous piano hinge with removable pins.

6. Locking Device: Key operated cylinder lock with 2 keys. Coordinate with Owner to insure that all access panels for Project operate by same key.

7. Anchors: Provide appropriate anchors for adjacent construction.

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2.03 FLUSH PANEL PLASTER CEILING ACCESS DOOR

A. **Acceptable Manufacturers**: Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milcor Limited Partnership, Melrose Park, IL; Style K

B. **Fabrication:**

1. Sizes: 24 inches by 24 inches, 24 inches by 36 inches, 30 inches by 36 inches, or 36 inches by 48 inches, for plaster surfaces.

2. Frame Material: 16 gauge steel.

3. Door Panel Material and Construction: 14 gauge steel.

4. Finish: Chemically bonded prime coat of baked enamel over a protective phosphate coating on the steel.

5. Hinge: Concealed spring hinges or continuous piano hinge with removable pins.

6. Locking Device: Key operated cylinder lock with 2 keys. Coordinate with Owner to insure that all access panels for Project operate by same key.

7. Anchors: Provide appropriate anchors for adjacent construction.

2.04 FLUSH PANEL DRYWALL CEILING ACCESS DOOR

A. **Acceptable Manufacturers**: Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milcor Limited Partnership, Melrose Park, IL; Style DW

B. **Fabrication:**

1. Sizes: 24 inches by 24 inches for drywall board surfaces.

2. Frame Material: 16 gauge steel.

3. Door Panel Material and Construction: 14 gauge steel.

4. Finish: Chemically bonded prime coat of baked enamel over a protective phosphate coating on the steel.

5. Hinge: Concealed spring hinges or continuous piano hinge with removable pins.

6. Locking Device: Key operated cylinder lock with 2 keys. Coordinate with Owner to insure that all access panels for Project operate by same key.

7. Anchors: Provide appropriate anchors for adjacent construction.

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PART 3 - EXECUTION

3.01 INSTALLATION

A. **Coordination:** Coordinate and ensure that access panels provided under this contract are built into the structure at the proper location and elevation and at the proper time. Furnish access panels to appropriate Contractors for installation into their work.

B. **Access Doors to Be Furnished:** Contractor shall furnish access doors at locations to service the following: Control and shut-off valves. Furnish access doors where shown on Drawings.

1. Contractor shall include the cost to furnish and install 5 extra panels in his Bid, minimum size of 24 by 24, for location during construction.

C. **Plumbing Fixture Chases:** Provide a 16 by 16 access panel at each plumbing chase for visual inspection purposes.

END OF SECTION

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PENETRATION SEALANTS FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories required to furnish and install through-penetration firestop systems at wall, floor and roof openings.

B. **Related Sections:**

1. Section 22 00 00: Plumbing - General Requirements
2. Section 22 07 00: Plumbing Insulation
3. Section 22 11 00: Facility Water Distribution

1.02 REFERENCES

A. **General:** The following references refer to the latest version of the standards listed.

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

1. ASTM E84, Surface Burning Characteristics of Building Materials
2. ASTM E814, Fire Tests of Through-Penetration Firestops

C. **Underwriters' Laboratories (UL):**

1. UL 1479, Fire Tests of Through-Penetrations Firestops
2. UL Building Materials Directory, Through-Penetration Firestop Systems (XHEZ), and Fill, Void or Cavity Materials (XHHW)

1.03 SUBMITTALS

A. **Instructions:** Submit manufacturer's instructions for applying sealant.

B. **Certification:**

1. Submit manufacturer's certifications that materials meet or exceed specified requirements.

2. Submit documentation of manufacturer's acceptance of applicator.

3. Provide certification stating that sealant has been completed in full accordance with requirements to provide necessary fire-resistance ratings.

4. Provide an electronic set (PDF) of certified test reports of:

   a. Fire test reports of sealant application to substrate materials shall be similar to project conditions.

   b. Reports from reputable independent testing agencies of product proposed for use, indicating conformance with ASTM E814.

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1.04 QUALITY ASSURANCE

A. **Qualifications:** Applicator shall be acceptable to sealant manufacturer.

B. **Regulatory Requirements:**

1. State Building Code Division
2. Local Codes and Ordinances
3. Local Authority having jurisdiction

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Bio-Fireshield, Inc., Concord MA 01742
2. Carborundum Company, Niagara Falls, NY 14302
3. Dow Corning Corporation, Midland, MI 48640
4. General Electric Company, Silicone Products Division, Waterford, NY 12188
5. Hilti-Ciba-Geigy, Tulsa, OK 74126
6. Metalines, Ind., Oklahoma City, OK 73147
7. 3M Company, St. Paul, MN 55144
8. Nelson Electric, a Unit of General Signal Corporation, Tulsa, OK 74101
9. Tremco, Inc., Beachwood, OH 44122
10. Rectorseal Corp., Houston, TX 77055

2.02 MATERIALS

A. **Description:** Penetration sealant shall be a one component ceramic fiber-based putty fill, void or cavity material or 3M fire barrier caulk, putty strip, and sheet forms.

B. **Applications:** Flame Spread/Smoke Contribution shall be 0/0 in accordance with ASTM E84. Underwriters' Laboratories rated material classified for use in Through-Penetration Firestop Systems shall be used for, but not limited to, the following:

1. Metal Pipe.

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PART 3 - EXECUTION

3.01 EXAMINATION

A. **Verification of Conditions:**

1. Confirm compatibility of surfaces to receive sealant materials.

2. Verify that openings are sound, clean, dry, and ready to receive application of sealants.

3. Verify that penetration elements are securely fixed and properly located, with a minimum of space between penetrations and surfaces of openings.

4. Beginning of installation means acceptance of existing conditions.

3.02 PREPARATION

A. **Damage:** Protect adjacent surfaces and equipment from damage.

B. **Cleaning:** Clean contact surfaces of dirt, dust, grease, oil, loose material or other matter which may affect bond of sealant.

1. Remove incompatible materials which affect bond by scraping, brushing, scrubbing or sandblasting.

3.03 MOCK-UP

A. **General Requirements:** Apply one seal on representative substrates on site for each fire rating required at each type of wall, floor and roof construction. Confirm requirements of fire ratings.

1. Application shall be in accordance with Project requirements as to thickness and density to achieve fire rating.

B. **Acceptance:** Product and application shall be approved by governing authorities prior to continuing with the Work.

1. Approved mock-up may remain as part of the completed Work.

3.04 APPLICATION

A. **Instructions:** Apply sealant in strict accordance with manufacturer's instructions.

B. **Rating:** Apply sealant in sufficient thickness to achieve required rating.

C. **Packing:** Pack material solidly around penetrations, fill openings to a depth as required by manufacturer's UL listing. Minimum shall be in accordance with 1, 2, and 4 hour fire rating as required.

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3.05 FIELD QUALITY CONTROL

A. **Inspection:** Perform inspection to verify that Work is in accordance with requirements.

1. Correct unacceptable Work and provide further inspection to verify that Work meets requirements.

3.06 CLEANING

A. **Material:** Remove excess material, droppings, and debris.

B. **Sealant:** Remove sealant from materials and surfaces not specifically required to be sealed.

3.07 PROTECTION

A. **General Requirements:** Protect applied sealant from damage.

END OF SECTION

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SECTION 22 07 00

PLUMBING INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment and accessories for the installation of thermal insulation for plumbing in strict accordance with insulation Section of the Specification and applicable Drawings.

B. **Related Sections:**

1. Section 22 00 00: Plumbing - General Requirements
2. Section 22 11 00: Facility Water Distribution

1.02 REFERENCES

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

1. ASTM E84-82: Test Method for Surface Burning Characteristics of Building Materials

B. **National Fire Protection Agency (NFPA):**

1. NFPA 255: Tests for Surface Burning Characteristics of Building Materials

C. **Underwriters' Laboratories (UL):**

1. UL 723

1.03 SUBMITTALS

A. **Shop Drawings:** Contractor shall submit a list of insulation to be used prior to beginning any application work.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

1.05 QUALITY ASSURANCE

A. **Regulatory Requirements:**

1. State Building Code

2. Local Codes and Ordinances

3. Local Authority having jurisdiction

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PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Johns Manville
2. Armacell LCC
3. Imcoa
4. Knauf
5. Owens-Corning
6. CertainTeed

B. **Insulation Materials:** Insulation materials manufacturing facilities must be certified and registered with an approved Registrar for conformance with ISO 9000 Quality Standard.

C. **Fire and Smoke Hazard Ratings:**

1. Insulation shall have composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to the insulation) fire and smoke hazard ratings as tested by procedure ASTM E84, NFPA 255 and UL 723 not exceeding:

   a. Flame Spread 25
   b. Smoke Developed 50

2. Accessories, including adhesives, mastics, cement tapes, glass fabric, and fire resistant cloth for fittings, shall have the same component ratings as listed above.

3. Products or their shipping cartons or packages shall bear a label indicating that flame and smoke ratings do not exceed above requirements. Stencil duct liners with "MEETS 90A REQUIREMENTS".

4. All insulation used for mechanical systems shall have the name of the manufacturer, the thermal resistance R-value at the specified installation thickness, and the flame spread and smoke-developed ratings of the composite materials.

2.02 MATERIALS

A. **Jackets and Facing Descriptions:** Poly-encapsulated paper jacket bonded to aluminum foil, reinforced with fiberglass yarn. Poly-encapsulated paper jacket to be permanently treated for fire and smoke safety, and to prevent corrosion of foil. Beach puncture 50 ox. in./in./year, tensile strength 35 pounds per inch width, Mullen Burst 70 psi, perm rating 0.02 perm. AP-T shall be a factory applied self-seal system and may be used at the Contractor's option.

1. FSK reinforced foil and paper (Foil Scrim Kraft). Aluminum foil, minimum 0.75 mil thick, reinforced with fiber glass yarn mesh and laminated to 40 pound chemically treated fire resistant Poly-encapsulated paper jacket, Underwriters' Laboratories rated.

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2. Dura Mesh glass fabric shall be white resin coated 10 by 10 mesh.

3. PVC pipe jacketing and fitting covers, high-impact, white, 20 mil, UV resistant PVC jacketing and preformed fitting covers applied with waterproof adhesive, all components meeting the 25/50 fire and smoke hazard ratings. Johns Manville Zeston 2000 with Perma-Weld adhesive.

B. **Inserts:** Install insulation inserts at outside hangers and supports for piping 1-1/2 inches and larger. Inserts between the pipe and pipe hangers shall be of equal thickness to the adjoining insulation and insulation saddles, and shall be provided with a vapor barrier. Insulation inserts shall be as manufactured by Pipe Shields Incorporated, Insul-Shield Uni-Grip or Johns ManvilleThermo 12/Gold. Shield shall be installed between hanger and insulation on all piping.

PIPE SIZE	"INSULATION" INSERTS NOT LESS THAN THE FOLLOWING LENGTHS	SHIELD LENGTH	MINIMUM GAUGE
Less than 1-1/2 Inches	—	10 Inches	26
1-1/2 Inch to 2-1/2 Inches	10 Inches Long	12 Inches	24
3 Inches to 6 Inches	12 Inches Long	14 Inches	20
8 Inches to 10 Inches	16 Inches Long	18 Inches	16
12 Inches and over	22 Inches Long	24 Inches	16

1. At hanger and support points for insulated piping, install an insert around the lower 1/3 circumference. Shields shall overlap inserts 1 inch on each side.

2. Insulation shields shall be installed between insulation and pipe hangers for all pipe sizes.

C. **Glass Fiber Insulation:** Johns Manville "Micro-Lok" AP-T, meeting ASTM C547 or approved equal, having average thermal conductivity not exceeding 0.23 Btu per inch per square foot per degrees F per hour at mean temperature of 75 degrees F.

D. **Elastomeric Foam Insulation:** Rubatex R-180-FS tubing insulation been compounded to meet the indicated flame spread and smoke density rating.

1. Insulation thicknesses of 3/8, 1/2, and 3/4 inch, tested independently, shall have a maximum fire/smoke rating of 25/50. Other thicknesses are rated at 25/100.

E. **Calcium Silicate Insulation:** Johns Manville Thermo-12/Gold, asbestos free color coded hydrous calcium silicate, meeting ASTM C533 or approved equal.

1. Insulate fittings and valves 3 inches and smaller with Ryder's Thermokote V cement to same thickness as adjacent pipe insulation. Insulate over 3 inches with mitered segments of pipe insulation wired in place and finished with Thermokote V Cement. Fittings for temperatures 600 degrees F and over shall be made up in double layer construction.

2. Seal canvas on pipe insulation and fittings with mildew resistant adhesive, Benjamin Foster 81-42W.

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F. **Flexible Cellular Polyolefin Foam (IMCOA) ASTM C534:**

1. Insulation: Imcoa, Imcolock with pre-slit longitudinal seam with each mating surface adhesive coated and protected with a mylar release liner.

   a. No external vapor barrier jacket shall be required if the water vapor permeability is 0.01 perm inch or less. Insulation which is U.V. stabilized can be exposed to sunlight and weathering without any special paint coating. The insulation can be directly buried underground without any protective jacket if the manufacturer warrants its underground use.

2. Description: Imcolock shall comply with ASTM C-534, UL94HBF, UBC42-1 Class I, ASTM E-84 25/50, NFPA 255, UL723.

a.	K Factor: ASTM C177	.24 at 75 degrees F .26 at 90 degrees F
b.	Moisture Vapor Transmission: ASTM E96	(0.0) Zero perm inch
c.	Minimum Service Temperature:	-110 degrees F
d.	Maximum Service Temperature:	210 degrees F
e.	Maximum Flame Spread: ASTM E84	25
f.	Maximum Smoke Developed: ASTM E84	50
g.	Shall contain no potential corrosive constituents associated with stress corrosion failure of copper tubing.	

h. Connection Method	Piping System Temperature Range	
1) Fuse-Seal Hot Melt Method	-110 degrees	+210 degrees
2) Contact Adhesive (Mfg. Approval)	-110 degrees	+210 degrees
3) Lap seal end joint tape recommended by insulation manufacturer	32 degrees	+210 degrees

G. **Hot Equipment Insulation:** Insulate surfaces with Johns Manville No. 814 Spin-Glass meeting ASTM C612, 3 pound density fiberglass board or Roxul RXL 30A, 3 pound density mineral wool board.

PART 3 - EXECUTION

3.01 PIPING SPECIALTIES REQUIREMENTS

A. **General Requirements:** Insulation shall be applied on clean, dry surfaces. Contractor shall clean and prepare all surfaces to be insulated prior to application.

1. Insulation shall be continuous through wall and ceiling openings and sleeves.

   a. Where insulated pipe passes through a fire rated wall, ceiling or floor, insulation shall stop at fire barrier face and start at opposite side. On cold water piping, the insulation shall carry through the sleeve with no unsealed joints.

2. Insulation on cold surfaces where vapor barrier jackets are used shall be applied with a continuous, unbroken vapor seal. Hangers, supports and anchors that are secured directly to cold surfaces shall be adequately insulated and vapor-sealed by cementing pieces of vapor barrier over and around same.

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B. **Fittings, Expansion Joints, Valve Bodies, Strainers, and Flanges:** Insulate elbows, tees, and valves with Johns Manville Zeston 2000 system of premolded PVC fittings and fiberglass inserts installed in accordance with manufacturer's instructions. Fittings may be insulated with 3/4 pound Microlite blanket compressed to 1/2 the thickness of adjoining pipe covering and secured with 3-ply jute twine or mitered pipe insulation segments secured with 3-ply jute twine and finished with Ryder's Thermokote No. 1 cement. After cement is dry, finish fittings with two coats Benjamin Foster 30-36 reinforced with Dura-Mesh or 6 ounce canvas overlapping adjacent jacket.

3.02 INSULATING PIPING

A. **General Requirements:** Insulate piping with Johns Manville Micro-Lok AP-T jacketed fiberglass, IMCOA insulation or approved equal as indicated.

1. Seal jacket laps and end laps with Insul-Coustic 215 or Chicago Mastic 17-465 applied to two surfaces.

2. Piping run in walls shall be fully insulated.

B. **Storm Piping:** Insulate storm drain piping below roof of building, including but not limited to horizontal and vertical piping, roof drain body below roof and piping encased in masonry or in a chase, with 1/2 inch fiberglass or IMCOA insulation.

C. **Vent Piping:** Insulate vent piping below roof for 15 feet from roof penetration with 1/2 inch thick insulation.

D. **Service Water Piping, Non-potable Water, Domestic Cold Water, Irrigation Water, Hot Water and Recirculated Hot Water Piping:** Insulate service water and domestic water piping with fiberglass or IMCOA insulation in accordance with the following schedule:

TEMPERATURES	CIRCULATING MAINS & RUNOUTS		
	UP TO 1-1/4 INCHES	1-1/2 TO 4 INCHES	OVER 4 INCHES
170 to 180 Degrees F	1.5	2.0	2.0
140 to 160 Degrees F	1.5	2.0	2.0
100 to 130 Degrees F	1.5	2.0	2.0
Less than 100 Degrees F	0.5	1.0	1.0

END OF SECTION

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FACILITY WATER DISTRIBUTION

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories necessary to furnish and install pipe and pipe fittings for new systems or the extension of existing systems as indicated on Drawings.

B. **Non-potable Water Piping:** All piping shown, noted or labeled on Drawings as non-potable water (i.e. piping after backflow preventer's, etc.) shall be the responsibility of the Plumbing Contractor to install up to and including the connection to each piece of equipment and/or system.

C. **Related Sections:**

1. Section 22 00 00: Plumbing - General Requirements
2. Section 22 05 23: General-Duty Valves for Plumbing Piping
3. Section 22 05 16: Expansion Fittings and Loops for Plumbing Piping
4. Section 22 05 29: Hangers and Supports for Plumbing Piping
5. Section 22 07 00: Plumbing Insulation
6. Section 22 40 00: Plumbing Fixtures

1.02 SUBMITTALS

A. **Shop Drawings - Backflow Preventer:** Submit a Shop Drawing portfolio showing number, type, and size of backflow prevention devices to be installed for approval by Architect/Engineer. Each component, variation, model number and option called out in this Specification is to be clearly marked/indicated in submittal for each item. Shop Drawings not complying will be subject to rejection and re-submittal.

1.03 REFERENCES

A. **American National Standards Institute (ANSI)**

B. **American Society of Testing and Materials (ASTM):**

C. **American Water Works Association (AWWA)**

D. **Cast Iron Soil Pipe Institute (CISPI)**

E. **Factory Mutual Engineering Corporation (FM)**

F. **National Bureau of Standards (NBS)**

G. **National Fire Protection Association (NFPA)**

H. **Plastic Pipe Institute (PPI)**

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1.04 QUALITY ASSURANCE

A. **Regulatory Requirements:**

1. State Plumbing Code
2. State Building Code
3. Local Codes and Ordinances
4. Local Authority Having Jurisdiction

PART 2 - PRODUCTS

2.01 STANDARDS

A. **General:** Piping shall meet the latest editions of the following Standards:

1. Copper Piping: ASTM B88
2. Galvanized Steel Pipe, Schedule 40: ASTM A53

2.02 MANUFACTURERS

A. **Acceptable Manufacturers for Strainers**: Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Crane No. 988-1/2 or Crane No. 989-1/2
2. Metraflex
3. Mueller
4. Grinnell

B. **Acceptable Manufacturers for Automatic Flow Control Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Griswald
2. Autoflow Inc.

2.03 WATER PIPING AND FITTINGS

A. **Interior Above Grade:**

1. Water piping 4 inches and larger shall be Type "L" hard copper tubing.
2. Fittings on water piping 4 inches and larger shall be shall be wrought copper fittings.
3. Water piping 3 inches and smaller shall be Type "L" hard copper tubing.
4. Fittings on water piping 3 inches and smaller shall be wrought copper fittings.

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2.04 UNIONS AND COUPLINGS

A. **Pipe Size 2 Inches and Smaller:** Unions shall be bronze for copper or brass pipe soldered joints.

B. **Pipe size 2 1/2 Inches and Larger:** Flanges shall be bronze flanges for copper or brass piping. Gaskets shall be 1/16 inch thick ring type of preformed synthetic rubber.

C. **Dissimilar Metals:** When changing from iron or steel to copper or brass, an insulating (dielectric) material shall be used to prevent corrosion caused by galvanic or electrolytic action. Teflon tape will not provide the dielectric protection required.

2.05 PIPING SPECIALTIES

A. **Unions - Plumbing:** Unions in copper piping and flanges shall be solder joint type. Flange gaskets shall be 1/16 inch thick.

B. **Strainers:** Strainers shall be Crane No. 988-1/2, Crane No. 989-1/2, or engineer approved equal, with stainless steel or monel mesh screen with reinforced ends and 2 inch pipe nipple and cap on discharge openings.

C. **Vacuum Breakers:** Water supply connections to fixtures which may have submerged outlets, including janitors closets or sink faucets with hose ends, or equipment which has inlet below the spill line, including dishwashers, boilers, or hose bibs, shall be provided with an approved vacuum breaking device or air gap arrangement on downstream side of shut-off valve.

1. Vacuum breakers shall be capable of preventing back-siphonage of polluted water into a potable water supply by use of a durable, silicone disc float.

2. Where vacuum breakers are installed upstream of shut-off valve, including hose reels or boilers, vacuum breakers shall be of pressure operating type or an acceptable backflow preventer.

D. **Traps - Plumbing:** Running traps or "P" traps shall be furnished and installed in the drain connection from each fixture and piece of equipment connected to the drainage system, except where another type of trap is indicated. Traps, including integral traps in floor drains, shall be in accordance with the Plumbing Code.

E. **Automatic Flow Control Valves:** Flow control valves shall be tamper proof, factory calibrated, automatic pressure compensating type. Each valve shall limit flow rates within a range of plus or minus 5%, regardless of system pressure fluctuations. Valve body material shall be suitable for the designed system piping requirements, with internal working parts of passivated stainless steel construction. Provide valves with a metal tag, chain and stamped for system identification. Provide nipples and quick disconnect valves for connection of flow measuring instrumentation. Automatic flow control valves shall be as indicated on Drawings. Automatic flow control valves may be used in lieu of flow indicators on hydronic systems.

1. Provide a shut-off valve after each flow control valve for branch main servicing.

   a. The shut-off valve may be integral with the flow control valve.

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PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. **Domestic Services:**

1. The Contractor shall rough-in for the water meter per Utility Department requirements and install meter where shown on Drawings.

2. Contractor shall install the meters per City Utility Department requirements. Provide strainer and shut off valves.

B. **Shut-Off Valves:** Furnish and install shut-off valves on water connections to all plumbing fixtures, on each side of water heaters and all equipment. Furnish and install shutoff valves in water piping to sections of building to allow servicing and also in water mains and branches where indicated on Drawings.

C. **Automatic Flow Control Valves (AFCV):** Provide automatic flow control valves in the domestic hot water circulating system, sizes/flows shall be as indicated on Drawings. See Section 23 05 30 for valve description. Provide a check valve and shutoff valve, in that order, downstream of the AFCV.

D. **Common Outlets:** Fixtures or other equipment having hot and cold water supplies with a common outlet and a shutoff valve after the mixing valve/tee shall be provided with swing check valves in the hot and cold water supply lines.

1. This shall include but not be limited to thermostatic mixing valves, kitchen spray rinses, hose reels and can washes.

E. **Existing Water Main:** Where new construction crosses or is within 5 feet of existing water main, water main shall be relocated or changed to AWWA Class 200, bell and spigot or mechanical joint, cast iron. Refer to Drawings.

F. **Water Main Crossing:** Where storm and sanitary piping cross a new or existing water main, the water main shall not have joints for 10 feet each side of the crossing.

G. **Pipe Routing:** This Contractor shall ascertain location of electrical panelboards and shall keep piping out of area above panelboards and for a distance of 3 feet 6 inches in front of and 1 foot 6 inches from each side of panelboards. This includes all VAV box control panels.

H. **Pipe Runs:** Piping shall be run substantially as shown on Drawings in the most direct manner, avoiding unnecessary joints. Changes necessary for piping to meet requirements of electrical panels or other aspects of building construction shall be made by Contractor without extra charge. Defective pipe, fittings, and valves that may have been installed shall be removed and replaced with new and good quality material.

I. **Pipe sizes:** Pipe sizes shown on Drawings are nominal, unless otherwise indicated.

J. **Pipe lengths:** Special lengths of pipe shall be cut accurately to measurements established at the site and worked into place without springing or forcing.

K. **Dissimilar Metals:** Wherever connections are made between dissimilar metals, non-conducting (dielectric) unions shall be used. Brass adapters and valves are acceptable.

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L. **Escutcheons:** Install escutcheons at wall, floor and ceiling penetrations by piping in exposed finished locations and within cabinets and millwork. Escutcheons shall be chrome plated unless otherwise noted in specifications or on Drawings.

M. **Unions - Plumbing:** Install unions or flanges in pipe connections to equipment and where shown on Drawings and details.

N. **Strainers:** Install strainers where indicated on Drawings of same size as pipe in which it is installed.

O. **Flexible Connectors:** Install a flexible connector at each pump outlet. Exercise special care to provide pipe alignment such that no offset from pump to pipe will occur in flexible connector.

1. For braided hose install horizontally, where possible, on the equipment side of shut off valves.

3.02 PREPARATION

A. **Cleaning:** Ream pipes and tubes. Clean off scale and dirt, inside and outside, before assembly. Remove welding slag or other foreign material from piping.

3.03 PIPE CONNECTIONS

A. **Union Connections:** Make connections to equipment and branch mains with unions.

B. **Copper Pipe Joints:** Copper joints shall be made with non-corrosive paste flux and solid string of wire solder. Flux shall contain less than 0.2 percent lead.

1. Joints in Copper Tubing: Joints and fittings in copper pipe and tubing shall be connected with 95-5 tin-antimony solder or 96-4 tin-silver solder and flux.

3.04 PIPE ROUTING AND GRADING

A. **Pipe Runs:** Route piping in an orderly manner and maintain proper grades. Install to conserve headroom and interfere as little as possible with use of space. Run exposed piping parallel to walls. Group piping whenever practical at common elevations. Install concealed pipes close to building structure to keep furring to a minimum.

1. Slope water piping 1 inch in 40 feet and arrange to drain at low points thru a fixture service. If no fixture is available install a ball valve with a 3/4 inch hose thread cap.

B. **Expansion/Contraction:** Install piping to allow for expansion and contraction without stressing pipe or equipment connected.

C. **Clearance:** Provide clearance for installation of insulation and for access to valves, air vents, drains, and unions.

END OF SECTION

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SECTION 22 40 00

PLUMBING FIXTURES

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, skills, and related services necessary to furnish and install plumbing fixtures and trim as indicated on the Drawings and specified.

B. **Related Sections:**

1. Section 22 00 00: Plumbing - General Requirements
2. Section 22 01 00: Operation and Maintenance of Plumbing
3. Section 22 05 53: Identification for Plumbing Pipe and Equipment
4. Section 22 11 00: Facility Water Distribution

1.02 REFERENCES

A. **American Society of Sanitary Engineers (ASSE)**

B. **U.S. Health Department**

C. **National Sanitation Foundation (NSF)**

1.03 SUBMITTALS

A. **Shop Drawings:** Contractor shall submit a portfolio showing fixtures and trimmings under the Plumbing Fixture List, for approval by Architect/Engineer or his authorized representative before roughing-in. Each component, variation, model number and option called out in this Specification is to be clearly marked/indicated in submittal for each fixture. Shop Drawings not complying will be subject to rejection and re-submittal.

1.04 QUALITY ASSURANCE

A. **Qualifications:** When a manufacturer's name and model number are specifically listed, it is intended to set a standard and style to be followed. Approved equal manufacturers shall meet that intended standard.

B. **Regulatory Requirements:**

1. State Plumbing Code
2. State Building Code
3. Local Codes and Ordinances
4. Local Authority Having Jurisdiction

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PART 2 - PRODUCTS

2.01 SPECIFIC REQUIREMENTS

A. **Faucets and Bubblers:** All faucets and bubblers shall meet ANSI/NSF Standard 61, Section 9 for drinking water system components, except janitor sink faucets and metering faucets.

2.02 MANUFACTURERS

A. **Acceptable Manufacturers for Commercial Plumbing Fixture Trim:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Dearborn Brass
2. Brasscraft
3. Engineered Brass Company
4. McGuire Manufacturing Co.
5. Zurn Commercial Traps & Supplies

B. **Acceptable Manufacturers for Stainless Steel Sinks:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Elkay
2. Just

C. **Acceptable Manufacturers for Manual Faucets:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Chicago Faucet Company
2. T&S Brass

D. **Acceptable Manufacturers for Wall and Roof Hydrants:** Wall Hydrants, freeze proof and non-freeze proof, shall be subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Woodford
2. Josam
3. Smith
4. Wade
5. Watts

2.03 FIXTURES

A. **General Requirements:** Plumbing fixtures shall be best quality and shall have manufacturer's guarantee label or trademark indicating first quality.

1. Size of connection to plumbing fixture is indicated by schedule shown on Drawings. Provide water supply to fixtures and equipment with chrome plated stop valves, including fixtures and equipment furnished by others.

2. Plumbing fixtures, equipment, and installation shall meet the requirements of the Plumbing Code.

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B. **Protection of Fixture:** Contractor shall be responsible for protecting plumbing fixtures included in this Specification against injury from building materials, acids, tools, and equipment by suitable wood covers. Cost of replacing and repairing plumbing fixtures shall be paid for by this Contractor.

2.04 PLUMBING FIXTURE LIST.

A. **Stainless Steel Counter Sinks:**

1. **Item F-6A Single Compartment Sink Accessible:** Elkay No. LR-2522-5-3 counter sink, 18 gauge, type 304 stainless steel, self-rim construction, 25 by 22 inches with 21 by 15 3/4 inch by 4 1/2 inch deep compartment, waste offset to the back of sink, brushed satin smooth finish, faucet drilling on 4 inch centers for 8 inch centerset faucet and underside undercoated. Install sink in countertop.

   a. Faucet: Chicago Faucet model No. 2300-225 chrome plated single lever mixing faucet for hot and cold supplies, deck mount, 8 inch center escutcheon plate for 3 hole installation, 8 inch tubular swing spout with 2.2 gpm soft-flo aerator.

   b. Drain: Chrome plated basket strainer with chrome plated 1 1/2 inch tailpiece.

   c. Supplies: Chrome plated lock-shield, loose-key supply stops with stuffing box, flexible supply offsets and escutcheon plates.

   d. Trap: Chrome plated 1 1/2 inch 17 gauge "P" trap with cleanout, offset waste to wall tubing, compression waste connection and escutcheon. "Note: Tailpiece and P-trap shall be off-set due to installation constrains with casework ADA panel. Contractor to coordinate with casework supplier."

B. **Roof Hydrants:**

1. Non-Freeze Roof Hydrants: Non-freeze Roof hydrants shall be Woodford concealed automatic draining, Model RHY@-MS, enclosed in a, with backflow preventer, 3/4 inch hose thread nozzle, 1-piece variable flow plunger to control both flow and drain functions, hardened stainless steel stem, polished brass finish on brass castings. Provide hydrant support and roof boot cover.

C. **Check Stop Valves:**

1. Check Stop Valves shall be Watts Regulator Series CS/CSC combination check/stop/strainer valve of bronze construction, incorporating materials suitable for its intended use. The check stop valve shall be fitted with a strainer and a union connection.

PART 3 - EXECUTION

3.01 FIXTURE INSTALLATION

A. **General Requirements:** Fixtures shall be furnished, set in place, and properly connected, complete in every detail to soil, waste, vent and water pipes. Fixtures shall be rigid, set plumb, level and true.

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B. **Hanging Fixtures:** Exercise particular care in hanging fixtures, especially lavatories, to ensure rigidity and permanence. Contractor will be held responsible for secure mounting of hangers and lavatories on hangers and breakage resulting from improper installation of fixtures.

1. On metal studs and partitions, backing shall be 1/4 inch by 6 inch steel plate welded or bolted to at least 3 studs. The steel plate shall be drilled and tapped, as required to receive concealed wall hanger for fixture carrier mounting bolts.

   a. If welded, not less than 3/16 inch electric arc fillet shall be made at top and bottom edges of plate and across full width of flange at each stud that it touches.

   b. If bolted, not less than 1/4 inch "U" bolts shall be used through plate and around flanges of each stud that it touches.

2. On concrete walls, securely fastened with heavy expansion bolts of required length and secure fixtures.

3. Fixture Bolts: Hang or support wall fixtures with 5/16 inch brass bolts of sufficient length to securely fasten fixture to backing. Chrome plate exposed heads of bolts for fixtures.

4. Secure the bottoms of the lavatories, electric water coolers and/or drinking fountains.

C. **Inlets:** Provide correctly faced inlets for fixtures.

D. **Waste Lines:** Connect fixture wastes, other than water closets and trap standard fixtures, to waste lines with an iron ferrule and threaded pipe. Make connections to floor set water closets and trap standard fixtures with cast iron floor flange with ring gasket and bolts for caulking into soil pipe. Closets and other trap standard floor connections joints shall be made tight without the use of putty. Extend branches of soil, waste, and vent pipe as close to fixture as possible. Branches of vent pipes shall be graded to the trap. Waste pipe shall be run in practical alignment at a uniform grade of not less than 1/8 inch to the foot and shall be supported and anchored at intervals not to exceed 10 feet.

E. **Chrome Plated Angle Supplies:** Provide chrome plated loose key angle stops in water supplies to water closets, lavatories, sinks and other fixtures. Exposed water supply piping below the fixtures shall be chrome plated except piping concealed in accessible cabinetwork may be copper.

F. **Miscellaneous Plumbing:**

1. Anchor flush valves for water closets and urinals absolutely shake-proof in walls.

2. Caulk around plumbing fixtures with a white silicone sealant.

G. **Roof Hydrants:** Mount Roof Hydrants using manufacturers roof deck mounting system with hydrant support, shims, underdeck flange and accessories.

H. **Check Stop Valves:** Install check stop valves at hot and cold water inlet supplies for all mixing and tempering valves and tees. Use at pipe sizes 1/2 inch, 3/4 inch and 1 inch. At sizes larger than 1 inch, the Contractor is to use separate isolation ball valve, check valve and strainer in hot and cold inlet supplies.

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I. **Escutcheons:** Install escutcheons at wall, floor and ceiling penetrations by piping in exposed finished locations and within cabinets and millwork. Escutcheons shall be chrome plated unless otherwise noted in specifications or on Drawings.

J. **Valving:** Install a full line size shutoff valve in each hot and cold water branch piping from mains and main branches, that extends to more than one fixture. Also install full line size shutoff valves in mains and main branches to sections of building, where required by code or local authority, and where shown on Drawings to allow for servicing.

3.02 CONNECTIONS TO EQUIPMENT FURNISHED BY OTHERS

A. **Fixtures:** Make connections to fixtures and equipment furnished by others as indicated on Drawings and furnish traps and stops in supplies to make a complete installation.

B. **Water Supplies:** The minimum hot and cold water rough-in size to kitchen equipment shall be 3/4 inch.

END OF SECTION

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SECTION 23 00 00

HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC) - GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Work included under this Division shall consist of furnishing labor and materials necessary for the installation of the work called for under the Mechanical Contract as listed in the Instruction to Bidders, as specified, and as shown on Drawings to provide a complete, operable and approved system. The Owner will contract directly with a Testing, Adjusting and Balancing Contractor, as specified in Section 23 05 93 and the Commissioning Authority, as specified in Section 23 08 00.

1. Job Progress: Contractor shall provide sufficient workers and materials to keep pace with the construction schedule. Contractor shall place orders for equipment such that job progress is not slowed due to late delivery and shall confirm delivery dates with suppliers.

2. Coordination: Contractor shall coordinate trades to install systems in the space provided within the structure. Where required, Contractor shall remove and reinstall existing work to allow for a congruous installation. Install systems and materials for ease of maintenance. Equipment arrangements shall provide at least the minimum clearances as recommended by equipment manufacturer to facilitate proper maintenance and servicing of system.

    a. Deviations in minimum clearance requirements shall be permitted only upon prior written authorization from the Architect/Engineer.

    b. Testing and balancing shall be scheduled after the Mechanical Contractor has given written documentation to the Test and Balance Contractor that systems are fully operational and building controls and graphics are complete. The Mechanical Contractor shall send a copy of this Documentation to the Engineer.

    c. Commissioning shall be scheduled after the Mechanical Contractor has given written documentation to the Commissioning Authority that systems are fully operational and building controls and graphics are complete. The Mechanical Contractor shall send a copy of this Documentation to the Engineer.

        1) Punchlists generated by the Commissioning Authority will not be inspected by the Commissioning Authority for completion until the Commissioning Authority has received written documentation, indicating that all punch list items have been completed. Closeout and final payments will not be authorized until all punch list items, generated by the Commissioning Authority and the Engineer, have been completed to the satisfaction of the Engineer.

B. **Related Sections:**

1. Section 01 11 00: Summary of Work
2. Section 01 23 00: Alternates
3. Section 01 33 00: Submittals Procedures
4. Section 01 61 00: Common Product Requirements
5. Section 01 73 29: Cutting and Patching
6. Section 01 77 00: Closeout Procedures

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C. **Drawings Use and Interpretation:**

1. The Drawings are diagrammatic and indicate the general arrangement of systems and equipment, unless indicated otherwise by dimensions or Detail Drawings. For exact locations of building elements, refer to dimensioned Architectural/Structural Drawings; however, field measurements take precedence over Dimensioned Drawings. The installation of all systems and equipment is subject to clarification as indicated in Division 1 - GENERAL REQUIREMENTS.

2. Piping and ductwork plans are intended to show size, capacity, approximate location, direction and general relationship of one work phase to another, but not the exact detail or arrangement.

3. Generally, layout pipelines requiring drainage first, followed by large pipe mains, ductwork and electrical conduit. Follow this procedure for an orderly installation but not to establish precedence of one trade over another.

4. Equipment outlines shown on Detail Drawings or dimensions indicated anywhere on the Drawings are limiting dimensions. Equipment exceeding approximate dimensions indicated by equipment outlines on Detail Drawings and any equipment or arrangements that reduce indicated clearances or exceed specific equipment dimensions may not be used.

D. **CADD Drawings:**

1. After an award of Contract, contractors may request electronic copies of our CADD Drawings.

2. Request for copies of the CADD Drawings shall be in writing and shall clearly indicate the specific sheets of the Drawings which are being ordered.

3. The following pricing shall apply:

a. $100.00 Per Sheet for Unit Information (i.e., Ventilation, Plumbing & Piping).

b. $100.00 Per Reference Plan / Building Plan per Floor.

1.02 REFERENCES

A. **Air Conditioning and Refrigeration Institute (ARI):**

1. ARI 435-78, Application of Central Station Air Handling Units

B. **American National Standard Institute (ANSI):**

1. ANSI B31.1, Pressure Piping - Power Piping

C. **American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE)**

D. **American Society of Mechanical Engineers (ASME):**

1. Boiler and Pressure Vessel Code: Section IX, Welding and Brazing Qualifications

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E. **American Society for Testing and Materials (ASTM):**

1. ASTM R84-81, Surface Burning Characteristics of Building Materials

F. **Air Moving and Conditioning Association (AMCA):**

1. AMCA 410-72, Recommended Safety Practices for Air Moving Devices

G. **Manufacturer's Standardization Society (MSS of the Valve and Fittings Industry, Inc.):**

1. MSS SP-58-1975, Pipe Hangers and Supports Materials, Design, and Manufacture
2. MSS SP-69-1976, Pipe Hangers and Supports Selection and Application

H. **National Electrical Manufacturers Association (NEMA)**

I. **National Fire Protection Association (NFPA):**

1. NFPA 90A, Air Conditioning and Ventilation Systems
2. NFPA 101, Life Safety Code

J. **Sheet Metal and Air Conditioning Contractors National Association (SMACNA)**

K. **Steel Tank Institute (STI)**

L. **Underwriters Laboratories (UL)**

1.03 DESIGN INTENT

A. **Mechanical System Overview:**

1. The building will be heated and cooled by outdoor air handling units.

2. Cooling source will be from Air Cooled DX Condensing Units.

3. The heating source will be from gas/oil-fired steam boilers through a steam to glycol/hot water heat exchanger.

4. Dedicated Outdoor Air Handling units are designed to supply 50 to 65 degrees F air.

5. VAV boxes with reheat will provide the necessary air quantities with discharge temperature modulated by the reheat coils for portions of the building.

6. VAV boxes with reheat will provide the necessary air quantities to displacement units in most classrooms.

7. Control system with be direct digital control. Computer, keyboard, CRT, and printer are located in the maintenance office for controlling and monitoring the system, including alarm reporting.

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B. **Design Criteria:**

Summer Outside Design:	92°F DB/74°F WB
Winter Outside Design:	-17°F DB
Summer Indoor Design:	78°F DB/50% RH
Winter Indoor Design:	72°F DB
Internal Loads:	245 BTU/Person Sensible
	205 BTU/Person Latent
Intended Occupancy:	7 AM to 4 PM Monday through Friday, **with frequently scheduled after hours usage.**

1. Load calculations were based on Low E glass having a U -value .5 and a shading coefficient of 0.26.

2. Outside air quantities and loads were based on occupancy as indicated in the VAV box schedule and adjusted per ASHRAE Standard 62-2007, equation 6.1. Air circulation quantities for classrooms, library, cafeteria, auditorium and stage generally have been designed at 1.2 CFM per sq. ft., corridors at .5 CFM per sq. ft.

C. **Design Criteria:**

1. Load Assumptions:

   a. IAQ (Indoor Air Quality) Criteria

      1) ASHRAE Standard 62-2007, equation 6-1.

2. Ventilation Rates:

   a. Outside Air is based on 10 CFM per student and 0.12 CFM per square foot for a classroom; and 5 CFM per person and 0.06 CFM per square foot for offices.

3. Occupancy Rates:

   a. Classrooms - 30 people

D. **Description of Systems:**

1. Heating System:

   a. Existing steam boiers feed steam to potions of the building and to new steam to glycol/hot water heat exchanger.

   b. Secondary pumping (two pumps, each sized for 50% flow) with variable speed controls are used to circulate to heating coils in air handling units, heating coils at VAV boxes, unit heaters, cabinet unit heaters, and radiation.

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c. Primary source of fuel for the boilers will be interruptible natural gas with #2 oil as backup fuel.

d. 30% ethylene glycol will be used in the hydronic heating loop.

2. Dehumidification System:

a. DX condensing units serve DOAS units with hot gas reheat coils

3. Ventilation:

a. Dedicated Outside Air System with central rooftop air handling units supplying displacement units through VAV boxes

1) Northeast Classrooms & Media Center

4. Energy Conservation Systems:

a. DOAS air handling units will incorporate energy wheels to condition ventilation air.

5. Controls and Building Automation:

a. Direct digital control system.

b. Central building computer control.

c. Electric actuators for control of valves and dampers.

d. Electronic temperature and humidity sensors:

1) Flat plate type for Public Areas.
2) Surface type non adjustable for Classrooms.
3) Surface type adjustable for Offices.

e. Electronic air flow measuring stations for determining proper ventilation rates.

f. Re-programming of local controllers can be done from the central system or at each controller.

g. Occupancy sensors will be used to reduce minimum outside air requirements for the air handling unit

6. Balancing:

a. Hydronic systems will be balanced to include heating pumps, flow at coils and heat exchanger.

b. Air systems will be balanced to include ventilation rates, room supply and return, exhaust, relief.

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E. **Special Construction Procedures:**

1. Use of Mechanical Systems during Construction:

a. Ventilation systems shall not be used until the building is dust free.

b. All equipment used during construction will be throughly cleaned, filters replaced, and rechecked.

c. All warranties shall start after the building has been accepted by the owner.

F. **Description of Commissioning Process:**

1. A review of the operation of the installed mechanical systems shall take place to insure that the systems are performing as per the design intent.

a. Spot checks of the testing and balancing report shall be made.

b. Systems shall be operated in the winter and summer modes, the day and night modes, the occupied and unoccupied modes, and the heating and cooling modes.

G. **Operation Considerations:**

1. Freeze protection

a. A 30% ethylene glycol solution shall be used in the hydronic (heating water) systems to protect the coils from freezing.

1.04 EXISTING SYSTEMS, EQUIPMENT, AND MATERIAL

A. **Hazardous Materials:** Under a previous contract asbestos-bearing materials have been removed or encapsulated. If asbestos-bearing materials, mercury-containing devices (such as thermostats, pneumatic-electric switches), or other hazardous materials are encountered, do not proceed with work in that location, but immediately inform the Owner so appropriate action can be taken.

B. **Remodeling:** Where relocations of existing equipment, and piping systems and materials is necessary in areas providing uninterruptible services, schedule the work for minimal down time during a slack period, if possible. Assign an adequate crew to accomplish the job in least possible time. Prefabricate and install interconnecting portions of these systems prior to shut-down for final connections.

1. Locate existing piping and make connection where required or where shown on the Drawings. Do not cut into existing services without verifying with the Owner that the pipe involved is the desired service. In any area where work performed under Division 23 is the only work involved, restore the area to its original condition upon completion of work.

2. Maintain all existing services and equipment unless otherwise shown on the Drawings.

3. Perform work that interrupts any service (this includes cutting into existing lines for new connections) at times (usually night) to cause the least interference to the normal operation of the building. Anticipate scheduling work at periods which will result in additional construction cost, such as nights and weekends, and include cost in the proposal.

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4. Inform the building engineering staff in advance of any shut-off that will occur and give an estimate of duration. Only after the engineering staff is fully informed and has agreed to the schedule of shut-offs, can the work then proceed accordingly.

5. All diffusers, coils, valves, thermostats, fixtures, piping, and other valuable equipment shall remain property of the Owner, except where noted otherwise, and stored on the site where directed.

C. **Connections:** Contractor shall field verify and inspect existing buildings for connections to existing systems, equipment, and materials designated, on Drawings or in Specifications, to be used.

1. Existing piping and ductwork that is disconnected and not reused shall be capped-leak tight below the floor, within the wall, or above the ceiling.

2. Requests for additional compensation will not be considered when such occurrence is the result of existing conditions.

1.05 SUBMITTALS

A. **General Requirements:** Refer to Section 01 33 00 for submission requirements.

B. **Operating Characteristics:** Submittals shall list actual proposed capacities of equipment submitted. Contractor shall indicate actual operating characteristics of proposed equipment at specified design conditions in the submittal.

C. **Review:** Review of Shop Drawings and other submittals will be general in nature and shall not be considered:

1. As permitting any departure from Contract requirements.

2. As relieving Contractor of responsibility for errors, including details, quantities, dimensions, and materials.

3. Contractor is responsible for reviewing all information in shop drawings related to the mechanical systems. Information includes, but is not limited to, the following: size, dimensions, electrical power requirements, hp, CFM, GPM, BTU, sound, system operating steam and/or gas pressure, pressure drops (water and air), and tonnage.

4. The Contractor shall highlight all differences between that which is being submitted and that which was specified.

D. **Samples:** Provide samples of material or equipment proposed to be furnished, if requested. Samples shall become the property of the Architect/Engineer and will be returned only when accompanied by a written request to do so.

E. **Record Drawings:** Refer to requirements as indicated in Section 01 77 00.

1. Record Drawings shall be provided in a hard copy and an electronic copy (PDF format).

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F. **Compatibility of Equipment:** Contractor shall have full responsibility of component parts of the mechanical system to ensure that new equipment, integrated with existing equipment and systems, will perform and operate in accordance with requirements of the Specifications without excessive or unusual service or maintenance requirements.

1. Should damage be sustained to existing fixtures, materials or equipment to be reused, relocated or to remain, the same shall be replaced with new material or equipment of equal or better quality as the Architect/Engineer directs.

2. It shall be the Contractor's responsibility to determine that changes in physical dimensions, access for maintenance, service line connections, structural supports, and vibration devices for substitute (approved equal) equipment are acceptable in the space provided for equipment and that performance characteristics are at least equal to base specification for equipment utilized from the substitutes (approved equals) listed.

3. Increased costs to provide additions or revisions required by acceptable manufacture's not used as basis of design and substitute (approved equal) manufacture's shall be the sole responsibility of this Contractor. Examples of additions or revision shall be as follows, but is not inclusive of all items:

   a. Electrical service connections revisions
   b. Additional equipment
   c. Wall and room layout revisions
   d. Structural support revisions
   e. Screen wall revisions
   f. HVAC connection revisions

G. **Critical Mechanical Equipment Submittals:** The Contractor shall submit the following Mechanical equipment shop Drawings within 15 days of award of Contract.

1. Energy Recovery Units
2. Air Handlers
3. VAV Boxes
4. HVAC Pumps
5. Diffusers
6. Condensing Units
7. Valve and Damper Schedules With Cut Sheets
8. Fire Stop

1.06 QUALITY ASSURANCE

A. **Qualifications:** Where equipment is specified by manufacturer, brand name or catalog number, this shall establish the standard of quality and style of the product to be provided under the Contract.

1. Where two or more units of the same kind of equipment are required, they shall be products of a single manufacturer. Mixing and matching of various manufacturer's like or similar components shall not be permitted.

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B. **Regulatory Requirements:**

1. State Building Code

2. National Electric Code

3. Local Codes and Ordinances

1.07 WARRANTY

A. **General Requirements:** Equipment furnished under this Contract shall have a one year warranty on parts and labor beginning at the date of substantial completion, unless a longer period is specified in the equipment specification section.

1.08 START-UP AND OPERATING REQUIREMENTS

A. Provide unit start-up by factory trained and authorized personnel for all Central HVAC, Heating and Cooling Equipment.

B. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, until building is clean, filters in place, bearings lubricated (if applicable), condensate properly trapped, piping connections verified and leak-tested, belts aligned and tensioned, all shipping braces removed, bearing set screws torqued, and fan has been test run under observation.

PART 2 - PRODUCTS

2.01 WALL, FLOOR, AND CEILING OPENINGS

A. **General Requirements:** This Contractor shall be responsible for locating chases and openings required for work in the general construction of the building.

B. **Chases and Openings:** The applicable Contractor shall be required to leave chases and openings in walls, floors, ceilings, and partitions where shown on Drawings or otherwise necessary to receive mechanical work.

2.02 SLEEVES

A. **General Requirements:** Provide sleeves in conjunction with ducts and pipes passing through concrete or masonry walls, partitions, and slabs. Provide sleeves in mechanical equipment rooms and chases to prevent water flooding from floor to floor, in addition to separating ductwork and piping from building structure.

1. Sleeves shall extend through full thickness of walls and slabs and shall be at least 2 pipe diameters larger than the pipe passing through. Where pipe with covering is installed, a minimum of 1/4 inch shall be provided between outside of pipe covering and inside surface of sleeve.

2. Core-drilled holes through solid masonry, concrete beams, or filled core concrete block walls, do not require sleeves.

3. Where pipes pass through existing walls or floors, holes shall be core-drilled.

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B. **Duct Sleeves:**

1. Material: Except as otherwise indicated, duct sleeves shall be constructed of minimum 22 gauge galvanized iron. Install sleeves in exterior walls below grade with approved caulking between sleeves and piping to make it waterproof.

2. Vertical Duct Sleeves: Vertical duct sleeves through floors shall have space between duct and sleeve packed with an approved fire stop material flush with top of sleeve to make a fire rated and watertight joint. Insulated duct shall have foamed rubber insulation full length within sleeves.

3. Placement: Set sheet metal sleeves for ductwork passing through floors above grade. Sleeve shall extend 3 inches above finished floor elevation. Sleeve shall be supported in place before floor is poured and shall be caulked to make a waterproof joint between floor and sleeve. Where more than one duct is passing through a floor slab above grade and one floor opening for all ducts is provided, sleeve shall be same size as opening.

4. Interior Sleeves: Ductwork through walls shall have soundproof packing (closed cell rod and sound caulking) in non-rated wall sleeves and an approved fire stop material in fire rated wall sleeves.

   a. Ducts passing through corridor walls, not containing fire dampers, shall be sleeved, flanged, and sealed, to prevent sound and air transfer.

5. Exterior Sleeves: Ductwork passing through exterior walls shall be sleeved and caulked watertight.

   a. Exterior ductwork shall be so installed as to pitch away from wall penetration a minimum of 1/4 inch per foot.

6. Fire Rated Wall and Floor and Roof Openings: Ductwork passing through fire rated walls, floors and roofs shall be provided as an Underwriters' Laboratories listed duct and sleeve assembly. Duct and sleeve assembly shall meet or exceed fire rating of wall and floor or roof which the duct passes through.

   a. Refer to Section 23 05 55, Penetration Sealants for HVAC Systems.

C. **Pipe Sleeves:**

1. Exterior Walls: Sleeves shall be standard weight steel pipe. Install sleeves in exterior walls and floors below grade with approved caulking between sleeves and piping to make it waterproof. Plastic sleeves shall not be used.

2. Floors: Sleeves shall be standard weight steel pipe vertical pipe sleeves through floors shall have space between pipe and sleeve packed with an approved fire stop material flush with top of sleeve to make a watertight and fire rated joint.

3. Interior Sleeves: Sleeves shall be standard weight steel pipe. Piping through walls of adjacent rooms shall have soundproof packing (closed cell rod and sound caulking) in non-rated walls and an approved fire stop material in fire rated walls.

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4. Fire Rated Wall and Floor and Roof Openings: Ductwork passing through fire rated walls, floors and roofs shall be provided as an Underwriters' Laboratories listed duct and sleeve assembly. Duct and sleeve assembly shall meet or exceed fire rating of wall and floor or roof which the duct passes through.

    a. Refer to Section 23 05 55, Penetration Sealants for HVAC Systems.

2.03 ENERGY REBATES

A. **General:** Contractor shall provide, for the Owner's use, one copy of the purchase orders or dealer invoices required by the power company to receive an Energy Rebate for the use of energy efficient/saving motors, desiccant wheels, and variable speed drives, Invoices shall indicate quantity and type (manufacturer, model number, horsepower or kilowatts and efficiency) of energy efficient/saving units provided.

PART 3 - EXECUTION

3.01 EXAMINATION

A. **Verification of Conditions:**

1. On-Site Review: Contractor shall visit site to become thoroughly acquainted with existing conditions of site and services.

2. Existing Active Services: When encountered in Work, Contractor shall protect, brace or support pneumatic tubing, existing active ductwork, or other services, where required, for proper execution of Work.

    a. If existing active services not indicated on Drawings are encountered, Contractor shall relocate and brace these services at no additional cost to Owner.

3. Inactive Services: If encountered in Work, Contractor, as appropriate, shall cap or plug inactive pipes, ducts, and temperature control wiring at no additional cost to Owner.

4. Responsibility: Liability for repairs or replacement of damaged or defective materials, including, but not limited to, property damage resulting from negligence or other causes, shall be the Contractor's sole responsibility until work has been accepted by Architect/ Engineer and Owner.

3.02 PREPARATION

A. **Protection:** After delivery, and before and after installation, equipment shall be protected against theft, injury or damage.

1. Contractor shall protect metal heating enclosures and other equipment, and all baked enamel or glazed surfaces from damage by covering or coating as recommended in Bulletin, "Handling and Care of Enameled Cast Iron Plumbing Fixtures," issued by Plumbing Fixture Manufacturers Association or by other methods approved by Architect/Engineer.

2. Coat polished or plate metal parts with Vaseline immediately after installation. Protect equipment outlets, pipe and conduit openings with temporary plugs, caps or burlap as required to prevent filling with construction dirt.

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3.03 EXCAVATION AND BACKFILL

A. **Backfilling Under Floors and Slabs**: Backfill areas below concrete slabs on grade in horizontal layers not to exceed 8 inches in depth and compact with approved equipment until dry density is not less than 95 percent of Standard Proctor Density.

1. Backfill material shall be pit run gravel or coarse sand free of rubbish, compacted and leveled to receive slab. If natural earth is of similar structure with same material as specified above, no additional material will be required.

   a. Fill to raise subgrades to required elevation shall be accomplished as specified above.

2. Materials and methods of compaction shall be approved by Architect/Engineer before start of work.

3. Areas not below concrete or asphalt slabs and footings shall be backfilled with suitable excavated material, free of debris and rubbish.

4. Contractor shall pay costs for testing of compacted backfill by an approved testing laboratory when tests are requested by Architect/Engineer.

B. **Backfilling Outside**: Backfill excavations below finished grades with materials similar to that removed in excavation, free from rubbish or other unsuitable material. Compact with approved equipment until dry density is not less than 95 percent of Standard Proctor Density.

1. Backfilling shall be done to finished grades indicated on Drawings. If no finished grading is done in excavated areas, Contractor shall backfill to existing grades and restore surface to original condition.

2. Compaction over ditches less than 3 feet in width and around walls and columns shall be done by the use of mechanical hand compactors.

3. Contractor shall pay costs for testing of compacted backfill by an approved testing laboratory when tests are requested by Architect/Engineer.

C. **Pavement, Curb, and Sidewalk Replacement**: Contractor shall be responsible for the replacement of existing street pavement, curbs and sidewalks removed or damaged by Contractor or related subcontractors, unless such pavement, curbs and sidewalks are to be reconstructed under the General Contract.

1. Make necessary arrangements to perform such repairs and pay incurred costs in connection with said repairs, including amount in Bid.

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3.04 CUTTING AND PATCHING

A. **General Requirements**: Cutting and patching shall be held to practical minimum consistent with good construction practice by properly locating and leaving sleeves and boxes, or notifying applicable Contractor of openings, where required, as construction progresses.

1. Necessary cutting and patching of walls, floors, partitions and ceilings, as required for the proper installation of work under this Contract, shall be the sole responsibility of this Contractor. Perform cutting and patching in such a manner as to leave no visible trace and to return the part affected to the condition of undisturbed work using the same material as presently installed. Cutting and patching shall be performed by workers experienced, skilled, and licensed for the particular type of work involved. Inferior work will not be accepted.

2. This Contractor is responsible for patching all holes/openings left in existing floors, walls, ceilings and roofs where mechanical equipment such as pipe, ductwork, etc. has been removed unless noted otherwise on the drawings. Patching shall be performed by workers experienced, skilled, and licensed for the particular type of work involved. Inferior work will not be accepted.

B. **Pavements**: Cutting of pavements shall be accomplished by saw cutting a minimum of 1 1/2 inches deep prior to jack hammering. Contractor shall bore below pavement where indicated on Drawings or where required by Architect/Engineer.

C. **Existing Conditions**: Patch pavements to match existing conditions. Labor and materials required to replace and rebuild parts cut or injured shall be furnished and installed by this Contractor.

3.05 INSTALLATION

A. **Connection to Equipment Specified**: Provide material and labor required to connect to the mechanical system of fixtures and equipment having mechanical connections and which are specified in other Sections or Divisions of the Specifications or furnished by Owner.

1. Provide piping supply connections with shut-off valves.

2. Ductwork connections to equipment, diffusers, and appurtenances shall be made with flexible ductwork unless a solid connection is indicated.

B. **Floor, Wall and Ceiling Plates**: Where uncovered exposed pipes pass through floors, walls or ceilings in finished rooms and inside casework, fit with approved type chrome plated metal plate.

1. Plastic escutcheon plates shall not be permitted.

C. **Mechanical Systems Painting in Unfinished Rooms (Mechanical Rooms, Boilers Rooms, Chiller Rooms, Etc.)**: Exposed supporting iron and steel work, bare pipe, fittings, hangers, and supports shall be wire brushed, washed with mineral spirits to remove dirt and grease, and painted with one coat of metal primer followed by two finish coats of battleship gray paint.

D. **Filtration**: Provide Three (3) sets of filters, one for during construction, one set prior to final balancing and one set delivered boxed to Owner at substantial completion.

1. At time of substantial completion, and prior to turning equipment over to Owner, Contractor shall deliver a complete set of unused, clean filters to the Owner for each unit supplying filtered air to the building.

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E. **Mechanical Equipment Mockup Requirements:** The Mechanical Contractor shall assist and supervise the completion of a mockup of each piece of mechanical equipment for which there is a Detail in the Mechanical Construction Documents. Also, provide mockup for fire stop material as indicated in Section 23 05 55.

1. The mockups when approved may remain as part of the final installation. The Contractor shall coordinate, with the Mechanical Engineer, the installation of the mechanical equipment as a standard of quality that is expected.

2. Before any additional installation work is started in other areas of the building, the Owner and the Architect/Engineer shall approve the mockup. The Contractor shall obtain approval of each mockup. Provide a three day notice to the Mechanical Engineer to schedule approval of the mockup.

F. **Lubrication:** After systems and equipment have been installed and just prior to building acceptance, properly lubricate motors and equipment installed for this project per manufacturers recommendations.

3.06 TESTS

A. **Heating:**

1. System Guarantee: Contractor shall guarantee that the installation shall operate with complete noiseless circulation of heating media through piping system, radiation and equipment.

2. Defects: Contractor shall be responsible for defects which develop in the systems caused by faulty workmanship, material or equipment and shall replace any such faulty workmanship, material or equipment during a period of one year from date of final acceptance. Acceptance of the work shall not waive the guarantee.

3. Tests: In the presence of the Architect/Engineer, or his duly authorized representative, the heating system shall be tested at 1 1/2 times the system design pressure, but not less than 100 psi hydrostatic pressure and proved drip-tight. Tests shall be complete before piping is connected to equipment or covered.

B. **Cooling:**

1. System Guarantee: Contractor shall guarantee that the installation shall operate with complete noiseless circulation of cooling media through piping system and equipment.

2. Defects: Contractor shall be responsible for defects which develop in the systems caused by faulty workmanship, material or equipment and shall replace any such faulty workmanship, material or equipment during a period of one year from date of final acceptance. Acceptance of the work shall not waive the guarantee.

3. Tests: In the presence of the Architect/Engineer, or his duly authorized representative, the cooling system shall be tested at 1 1/2 times the system design pressure, but not less than 100 psi hydrostatic pressure and proved drip-tight. Tests shall be complete before piping is connected to equipment or covered.

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C. **Ventilation:**

1. Contractor shall guarantee complete uniform circulation of air through ventilated spaces without objectionable noise. Contractor shall assume responsibility for and replace any faulty workmanship, material or equipment during a period of one year from date of final acceptance.

D. **Temperature Control:**

1. Contractor shall be responsible for defects which develop in any part of the system caused by faulty workmanship, material or equipment and shall replace any such faulty workmanship, material or equipment during a period of one year from date of substantial completion.

a. Instruments shall be calibrated to sense, activate and display information specified.

b. Acceptance of the work shall not waive this guarantee.

3.07 CLEANING

A. **Housekeeping, Cleaning and Storage**: Remove from the building and site, scrap material, temporary building, packaging material, miscellaneous debris, and dirt on a regular schedule, or as required, and in accordance with Architect/Engineer's direction, to maintain building in a reasonably clean, workable condition during construction.

1. Cutting oil and steel shavings shall be caught in a suitable container to ensure final finish material in building will not be marred or damaged.

2. Upon completion of work and before final inspection, Contractor shall remove plaster, paint, rust, stickers, and shipping tags from installed equipment.

a. Clean foreign matter from installed equipment and remove dirt and debris, in connection with work, from building.

3.08 MECHANICAL LIST OF CONSTRUCTION CLOSEOUT DOCUMENTS

A. The Contractor and their subcontractors should proceed immediately to fully complete the work as listed in Appendix 'A' at the end of this Section. The Contractor responsible shall initial and date the "Contractor Completed" column after each item as it is completed and forward a copy of the fully completed punch list to the engineers for their final approval.

(Refer to Following Pages for Appendix)

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Appendix 'A'

Section	Document Description	Contractor Date Comp./By	ATS&R Approved
23 00 00	Heating record drawings.	____/____	____
23 00 00	Ventilation record drawings.	____/____	____
23 00 00	Provide invoices for energy rebates on premium efficiency motors.	____/____	____
23 00 00	Provide invoices for energy rebates on variable speed pumping.	____/____	____
23 00 00	Provide invoices for energy rebates on variable speed drives for fans.	____/____	____
23 00 00	Provide documentation that new filters for all air handling units have been installed at time of substantial completion.	____/____	____
23 00 00	Document that hydrostatic pressure test has been completed on the heating water system.	____/____	____
23 01 00	Heating operation and maintenance manuals.	____/____	____
23 01 00	Ventilation operation and maintenance manuals.	____/____	____
23 01 00	Maintenance and lubrication schedule (heating).	____/____	____
23 01 00	Maintenance and lubrication schedule (ventilation).	____/____	____
23 01 00	Filter maintenance schedule.	____/____	____
23 01 00	Document instruction on heating water system.	____/____	____
23 01 00	Document instruction on ventilation system.	____/____	____
23 05 14	Document that variable speed pumping system has been adjusted to meet installed conditions.	____/____	____
23 05 14	Document that the Owner has been provided start-up service and training by an authorized factory certified technician for the variable frequency drives (see detail start-up instructions).	____/____	____
23 05 23	Valve tag schedule (heating & cooling).	____/____	____
23 05 23	Provide a typewritten list identifying all numbered valves and submit with operation and maintenance manual.	____/____	____
23 05 30	Provide Owner with 4 pressure gauge adapters with 1/8 inch outside diameter probe and four 5 inch stem pocket testing thermometers for use on Pressure - Temperature Test Stations.	____/____	____
23 05 93	Document that a Pre-Test and Balance meeting was held with the Engineer.	____/____	____
23 05 93	Provide test and balance data for the hydronic systems.	____/____	____
23 05 93	Provide test and balance data for the ventilation systems.	____/____	____
23 09 23	Energy Management and Temperature Control operation and maintenance manuals.	____/____	____
23 09 23	Document that the Owner has received training on the Energy Management and Temperature Control.	____/____	____
23 09 23	Document acceptance test of the Energy Management and Temperature Control.	____/____	____
23 09 23	Document verification and calibration of the Energy Management and Temperature Control.	____/____	____

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23 09 23	Document that each air handling unit will shutdown from the duct smoke detectors as specified.	_____/_____	_____
23 21 23	Document that the disposable fine mesh strainer has been removed after pump start-up for each suction diffuser.	_____/_____	_____
23 21 23	Document that a qualified millwright has checked and aligned each pump prior to start-up.	_____/_____	_____
23 25 00	Document that heating water system piping has been pre-cleaned as indicated.	_____/_____	_____
23 25 00	Document that a new strainer screen was installed prior to filling heating system for operation and after pre-operational system cleanout.	_____/_____	_____
23 25 00	Document test of glycol water systems before system is turned over to Owner.	_____/_____	_____
23 25 00	Document test of glycol water systems prior to end of first year of operation and replenish as required.	_____/_____	_____
23 33 00	Document all fire dampers, smoke dampers, and ceiling dampers have been operated, prior to the occupancy of a building, to determine that they function in accordance with NFPA.	_____/_____	_____
23 75 13	Document that the custom rooftop air handling unit(s) have been installed and are operating per the manufacturer's recommendations.	_____/_____	_____
23 75 13	Provide documentation that new filters for all custom rooftop air handling units have been installed at time of substantial completion.	_____/_____	_____
23 81 26	Document that the spot cooler(s) have been installed and are operating per the manufacturer's recommendations.	_____/_____	_____

END OF SECTION

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OPERATION AND MAINTENANCE OF HVAC SYSTEMS

PART 1 - GENERAL

1.01 OPERATION AND MAINTENANCE MANUALS

A. This Section is in addition to the Division 1 O&M Manual requirements.

B. The Operations and Maintenance (O&M) Manuals shall be submitted in paper and electronic formats. This Contractor shall complete and submit 3 copies of each O&M Manual section (main tab) within 30 days of the respective submittal acceptance. These will be reviewed for compliance and acceptability by the Architect/Engineer and Commissioning Authority.

1. Electronic format shall be provided on CD in format acceptable to the Owner.

C. Sixty (60) days prior to the original scheduled Substantial Completion Date, this Contractor shall compile the individual O&M Manual sections and submit 3 complete copies to Architect/Engineer. The Contractor shall compile O&M Manuals for every piece of equipment and building operating system according to the following requirements:

1. Format: 8 1/2 x 11 inches loose leaf binders. Each binder shall be clearly labeled on the spine. Use as many as required. Do not overload binders. Use dividers with permanently marked tabs of card stock separating each section and subsection. Tab labels must be easily readable and not handwritten.

2. Each binder shall be composed of:

a. Title Page

b. Table of Contents

c. Main Tab for each Specification Section

d. Sub-Tab for each piece of major equipment (or group, if small or numerous)

3. Each sub-tab shall be similar to the main tab for the Specification Section, but of a different color. Inside each equipment sub-tab shall be the following sections, in the given order, divided by a double-weight colored sheet labeled with the title of the section.

a. Contractor: Record the name, address and telephone number of the manufacturer and installing Contractor and the 24-hour number for emergency service for all equipment in this sub-tab, identified by equipment.

b. Submittal and Product Data: This Section shall include all approved submittal data, cut sheets, and appropriate shop Drawings. If a submittal was not required for approval, include descriptive product data.

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c. Operation and Maintenance Instructions: Shall be the written manufacturer's data with the model and features of this installation clearly marked and edited to omit reference to products or data not applicable to this installation. This Section shall include data on the following:

1) Installation, startup and break-in instructions and reports.

2) All starting, normal shutdown, emergency shutdown, manual operations, seasonal changeover and normal operating procedures and data, including any special limitations.

3) O&M and installation instructions that were shipped with the unit.

4) Preventive maintenance and service procedures and schedules.

5) Troubleshooting procedures.

6) A parts list, edited to omit reference to items that do not apply to this installation.

7) A list of any special tools required to service or maintain the equipment.

8) Performance data, ratings, and curves, including at least five (5) part load points (i.e., 20, 40, 60, 80, 100% load) for the expected range of operating conditions (i.e. 50°F to 55°F supply air temperature and -20°F to 95°F outdoor air temperature).

9) Warranty, which clearly lists conditions to be maintained to keep warranty in effect and conditions that would affect the validity of the warranty.

10) Any service contracts issued.

11) A maintenance and lubrication schedule (Refer to Appendix 'B' at the end of this Section for a blank form) shall include each motor, function, control location, fuse location, type of lubricant, and rate of lubrication in accordance with manufacturer.

12) A filter maintenance schedule (Refer to Appendix 'C' at the end of this Section for a blank form) shall include filter size and quantity for each unit, located by room number.

d. Control Drawings: Include the control Drawings for the piece of equipment and its components, including the sequence of operation. This Section will be electronically provided by the Controls Subcontractor for integration by the responsible subcontractor.

e. Specifications: This Section is comprised of the component or system specification section copied and inserted, including all Addenda.

f. System Description: This Section shall include the individual equipment portion of the overall system design documentation narrative. It will contain simplified professionally drawn single line system diagrams on 8 1/2 x 11 inches or 11 x 17 inch sheets, showing all controls, connections and interfaces.

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g. Preventive Maintenance Instructions: This Section shall include condensed, typewritten excerpts from the manufacturer's written instructions for weekly, monthly, quarterly, annual, etc., maintenance. This summary shall be prepared by the responsible Contractor with help from the equipment supplier. It shall be prepared for all installed equipment. This Section should include checklists for each task required.

h. Supplemental Data: When manufacturer's standard printed data is not available or the information necessary for a proper understanding and O&M of equipment or systems is missing, supplemental data shall be developed by the responsible Contractor for the equipment. This data shall be written text and simple schematic Drawings.

i. Include a warranty letter in the O&M Manual, to include the starting date(s) of warranty period(s) (including delayed start warranties and extended warranties) and duration of warranty periods. Warranty date should correspond to substantial completion date established by the Contract Documents.

1.02 INSTRUCTION

A. **General Requirements:** At the completion of the Project, when all systems are operating, the Contractor or his representative shall provide a minimum of 2 day(s) instruction period for Owner's personnel on the mechanical equipment excluding temperature control system. Training for the temperature control system is indicated in Section 23 09 23.

1. Instruction shall take the form of classroom sessions to introduce the HVAC operation, maintenance, and management personnel to the manuals, drawings, and other documents and aids available to operate and maintain the HVAC equipment and systems.

2. Instruction shall provide sufficient information to allow Owner's personnel to understand and operate all equipment and components.

3. Contractor shall coordinate and assist Owner to allow for video taping of on-site training if Owner chooses to do so.

4. A factory specialist in the area of major equipment and systems will present sessions on their specific equipment or system, or both.

5. Visual aids, such as slides and video shall be used during training and made part of the user's permanent files to be used for reference, refresher, and retraining. Provide electronic DVD of training for Owner's use.

6. See Appendix 'A' at the end of this Section for training agenda format.

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B. **Training:**

1. All training is to be scheduled 14 days in advance. All scheduling will be coordinated through Director of Buildings and Grounds.

2. At the time of the request, a written training agenda will be submitted, with the request to schedule, to Director of Buildings and Grounds. This allows the District to have the appropriate personnel involved. Contractor is to prepare an attendance verification form (Refer to Appendix 'D' at the end of this Section) to be signed by all participants. Architect in conjunction with Owner's staff will provide specified training requirements to Contractors at the Pre-Construction Meeting.

3. Substantial completion certificate will not be issued until all training is satisfactorily completed.

4. Training shall be more than a general review of equipment. The goal is to completely prepare personnel for system operation and maintenance.

5. All summer/winter change-over methods shall be provided in written form as related to the specific project. This shall be provided at the training session. Until this process is completed, the Contractor shall be responsible for all change-over and winter protection of the equipment.

6. All training shall be provided during the regular work day, 7:30 a.m. to 3:30 p.m.

7. Energy Management Training shall be provided for two individuals. Training shall be at a minimum of off-site technician level.

8. The Contractor shall provide a certificate indicating the date(s) the training was given, the hours of training, a list of the documentation given to the Owner, the names of individuals (including Company Name and Telephone Number) providing the training, the names of Owner's personnel receiving the training, and a list of the equipment/systems the training was provided for. This certification shall be signed and dated by a representative of the Owner. A copy of all the certifications shall be given to the Owner and the Architect/Engineer prior to the closeout of the project.

PART 2 - PRODUCTS

2.01 WALL, FLOOR, AND CEILING OPENINGS

A. **General Requirements:** This Contractor shall be responsible for locating chases and openings required for work in the general construction of the building.

B. **Chases and Openings:** The applicable Contractor shall be required to leave chases and openings in walls, floors, ceilings, and partitions where shown on Drawings or otherwise necessary to receive mechanical work.

PART 3 - EXECUTION

Not Used

(Refer to Following Pages for Appendices)

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Appendix 'A'

TYPICAL HVAC TRAINING AGENDA*

1. Opening Remarks.

2. Introduction.

3. Description of HVAC Systems:

   A. Air Side:

      1) Cooling
      2) Heating
      3) Ventilation
      4) Life Safety

   B. Wet Side:

      1) Cooling
      2) Heating

4. Description of Equipment and Systems (Individual Suppliers will discuss their equipment).

   A. Wet Side:

      1) Chiller (or Refrigeration Equipment)

         a. Accessory Equipment
         b. Electrical
         c. Control
         d. Refrigerant Piping

      2) Chilled Water

         a. Pumps
         b. Exchangers
         c. Piping
         d. Controls
         e. Water Treatment
         f. Electrical
         g. Control

      3) Boilers (Steam Generators)

         a. Water Make-Up
         b. Water Treatment
         c. Piping
         d. Controls
         e. Safety Accessories
         f. Electrical

      4) Insulation

   B. Air Side:

      1) Air Handling Units (Fans)

         a. Fans
         b. Coils
         c. Humidifiers
         d. Controls
         e. Electrical
         f. Isolation
         g. Insulation

      2) Terminal Boxes

         a. Fans
         b. Coils
         c. Controls

      3) Duct System

         a. Type(s)
         b. Pressure(s)

      4) Filter System

   C. Controls:

      1) Type System
      2) Purpose

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Appendix 'A' (cont.)

5. Walk-Through of Building.

6. Start-Up Procedures:

   A. Seasonal Considerations
   B. Check List
   C. Emergency Procedures

7. Operation Procedure:

   A. Occupancy Considerations
   B. Seasonal Considerations (Changeover)
   C. Manual/Automatic
   D. Emergency

8. Shut Down:

   A. Check List
   B. Normal
   C. Emergency

9. Maintenance (list major equipment systems):

   A. Routine
   B. Periodic
   C. Service
   D. Lubrication
   E. Overhaul
   F. Factory

10. Warranties:

    A. What they cover
    B. How to use them

11. Spare Parts.

12. Tools:

    A. Normal tools, supplies and equipment
    B. Special tools

13. Hands-on operation of HVAC equipment and systems in conjunction with HVAC preliminary commissioning.

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Appendix 'B'

MAINTENANCE AND LUBRICATION SCHEDULE								
UNIT NO.	ROOM NO.	FUNCTION	CONTROL LOCATION	FUSE LOCATION	TYPE OF LUBRICANT	RATE OF LUBRICATION	LUBRICATION DATE	NOTES

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Appendix 'C'

FILTER MAINTENANCE SCHEDULE							
AIR HANDLING UNIT NO.	ROOM NO.	PRE-FILTER SIZES	QUANTITY	FINAL FILTER SIZES	QUANTITY	REPLACEMENT DATE	NOTES

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Appendix 'D'

TRAINING DOCUMENTATION

This form documents that the Owner's representative has received training by the Contractor.

Date: _____

Site: _____

Owner's Representative: _____

Signature: _____

Contractor: _____

Contractor Representative: _____

Signature: _____

Training Duration (hours): _____

Description of Training Received: _____

END OF SECTION

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COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 REFERENCES

A. **National Electrical Manufacturers Association (NEMA)**

1.02 ELECTRICAL REQUIREMENTS FOR MECHANICAL SYSTEMS

A. **Motors and Starters:**

1. Motors required by equipment furnished under Division 23 shall be in accordance with the electrical requirements specified under Division 26.

a. Motors supplied with equipment furnished under Division 23 shall be Yaskawa E-plus or E-plus 3, Reliance XE, or equal, energy efficient motors. Electric motor efficiencies shall be equal to, or greater than, the requirements of Xcel Energy NEMA **Enhanced Premium** Efficiency Standards as listed in the following Table:

MOTOR ENHANCED PREMIUM EFFICIENCY STANDARDS							
OPEN DRIP-PROOF (ODP)				TOTALLY ENCLOSED FAN-COOLED (TEFC)			
HP	1200 RPM	1800 RPM	3600 RPM	HP	1200 RPM	1800 RPM	3600 RPM
1	83.5	86.5	78.0	1	83.5	86.5	78.0
1.5	87.5	87.5	85.0	1.5	88.5	87.5	85.0
2	88.5	87.5	86.5	2	89.5	87.5	86.5
3	89.5	90.5	86.5	3	90.5	90.5	87.5
5	90.5	90.5	87.5	5	90.5	90.5	89.5
7.5	91.2	92.0	89.5	7.5	92.0	92.7	90.5
10	92.7	92.7	90.5	10	92.0	92.7	91.2
15	92.7	94.0	91.2	15	92.7	93.4	92.0
20	93.4	94.0	92.0	20	92.7	94.0	92.0
25	94.0	94.6	92.7	25	94.0	94.6	92.7
30	94.6	95.1	92.7	30	94.0	94.6	92.7
40	95.1	95.1	93.4	40	95.1	95.1	93.4
50	95.1	95.5	94.0	50	95.1	95.5	94.0
60	95.5	96.0	94.6	60	95.5	96.0	94.6
75	95.5	96.0	94.6	75	95.5	96.4	94.6
200	96.4	96.8	96.0	200	96.8	97.2	96.4
NOMINAL FULL LOAD EFFICIENCIES. MOTORS USED ON MECHANICAL EQUIPMENT MUST MEET OR EXCEED THE NOMINAL ENERGY EFFICIENCY LEVELS PRESENTED ABOVE.							

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b. Motors supplied with equipment furnished under Division 23 that are operated through a variable frequency drive shall be provided with factory mounted motor-shaft ground system and the motor shall be invertor duty type.

c. Motor insulation shall meet NEMA MG1 Part 31 requirements.

2. Motor starters required by equipment furnished under Division 23 of the Specifications shall be furnished under Division 26, except starters that are specified to be furnished with equipment under Division 23. Starters shall meet the requirements of Division 26.

3. Contractor shall note electrical power will be supplied as 208 volt, 3 phase, 60 Hertz to motors and equipment 1/2 horsepower and larger and 120 volt, single phase, 60 Hertz to motors and equipment less than 1/2 horsepower.

B. **Electrical Controls and Wiring:** Provide motors, relays, transformers, and manual or automatic controls required for operation of mechanical equipment and systems. All equipment shall be listed per NEC.

1. Electrical conduit and wiring required to connect pilot, safety, temperature, pressure devices, control relays, and pilot lights required for controlling and interlocking mechanical equipment and systems shall be provided under Division 23 of the Specifications.

2. Install and connect controls and wiring in accordance with Contract Drawings and Division 23 of these Specifications. Work shall be in accordance with state and local codes and ordinances.

a. Contractor shall provide required electrical connections, including but not limited to, wiring and conduit for a complete, operable, and approved system, unless noted otherwise.

b. Conduit and wiring shall meet the requirements of Division 26.

PART 2 - PRODUCTS Not Used

PART 3 - EXECUTION Not Used

END OF SECTION

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SECTION 23 05 14

VARIABLE FREQUENCY DRIVES FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories necessary to furnish and install complete variable frequency motor drive controller consisting of a pulse width modulated inverter, for use on a standard NEMA Design B induction motor.

1. Variable frequency systems shall be for continuous duty and shall be suitable for use on motors connected by power transmission components to HVAC equipment.

B. **Related Sections:**

1.	Section 23 00 00:	Heating, Ventilating, and Air-Conditioning (HVAC) - General Requirements
2.	Section 23 05 29:	Hangers and Supports for HVAC Piping and Equipment
3.	Section 23 05 48:	Vibration and Seismic Controls for HVAC Piping and Equipment
4.	Section 23 05 93:	Testing, Adjusting, and Balancing for HVAC
5.	Section 23 07 00:	HVAC Insulation
6.	Section 23 09 23:	Direct-Digital Control System for HVAC
7.	Section 23 09 93:	Sequence of Operations for HVAC Controls
8.	Section 23 75 13:	Custom-Packaged, Outdoor, Central-Station Air-Handling Units

1.02 REFERENCES

A. **Institute of Electrical and Electronic Engineers (IEEE):**

1. IEEE Standard 519: Guide for Harmonic Control and Reactive Compensation of Static Power Converters

B. **National Fire Protection Association (NFPA):**

1. NFPA National Electrical Code (NEC)

C. **National Electrical Manufacturers Association (NEMA):**

1. NEMA MG-1, Motors and Generators

D. **Underwriters' Laboratories (UL)**

1.03 SYSTEM DESCRIPTION

A. **Performance Requirements:** Variable frequency speed drive controller shall be capable of accepting an electronic signal to determine quantity of air required and resultant frequency and voltage output to satisfy conditions.

1. Unit shall require one incoming power connection. Wiring from AFD controller to motor shall be by Electrical Contractor.

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1.04 SUBMITTALS

A. **Shop Drawings**: Provide a portfolio to include the following for approval by Architect/ Engineer.

1. Submit manufacturer's performance data including dimensional Drawings, customer connection Drawings, power circuit diagrams, installation and maintenance manuals, warranty description, and VFD's full load amp ratings, certification agency file numbers and catalog information.

1.05 QUALITY ASSURANCE

A. **Qualifications**: It is required that the drive manufacturer shall have the following:

1. A sales representative exclusively for HVAC products, with expertise in HVAC systems and controls.

2. An independent service organization.

3. A parts stocking depot local to the installation site.

B. **Factory Tests**: To ensure quality and minimize infantile failures at the jobsite, the complete VFD shall be tested by the manufacturer. The VFD shall operate a dynamometer at full load and the load and speed shall be cycled during the test.

1. Optional features shall be functionally tested at the factory for proper operation.

2. Optional features shall be factory mounted, wired, tested and complete with U.L. or ETL listing as an assembled package.

C. **Regulatory Requirements**:

1. State Building Code

2. Local Codes and Ordinances

3. Local Authority having jurisdiction

D. **Testing**:

1. All printed circuit boards shall be completely tested and burned-in before being assembled into the completed AFD. The AFD shall then be subjected to a preliminary functional test, minimum eight hour burn-in, and computerized final test. The burn-in shall be at 104°F (40°C), at full rated load, or cycled load. Drive input power shall be continuously cycled for maximum stress and thermal variation.

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PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers**: Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. ABB
2. Danfoss
3. Yaskawa

2.02 VARIABLE FREQUENCY INVERTER

A. **General**: System shall be a complete variable frequency drive as specified herein for the fans and air handling units scheduled at the end of this Section. Both the standard and optional features shall be included within the VFD enclosure, unless otherwise specified.

1. VFD enclosure shall be NEMA 1 and not exceed 12 inches in width.

2. Provide a lockable input disconnect switch to aid in VFD service. This disconnect shall function as the motor disconnect when in sight of the motor.

3. Each VFD vendor shall review the one line power distribution drawing(s), included for reference with the Mechanical Drawings, and calculate the voltage and current distortion induced by all the VFDs at full speed.

    a. If the THD (Total Harmonic Distortions) exceed the IEEE 519 guidelines of 5 percent voltage THD and 20 percent current THD as calculated, the VFD vendor shall include the necessary harmonic mitigation equipment sufficient to reduce the THD to the allowable level.

B. **Converter Section**: The VFD shall include a converter and an inverter section. The converter section shall convert fixed frequency and voltage AC utility power to DC voltage.

1. Each VFD shall include input line reactors of a minimum 1.5 percent impedance.

C. **Inverter Section**: The inverter section of the VFD shall invert the DC voltage from the convertor into a quality output wave form, with adjustable voltage and frequency for stepless motor speed control. The VFD shall maintain a constant squared volts to Hertz ratio.

D. **Modulation Range**: The VFD shall convert three-phase 60 Hz utility power to adjustable voltage and frequency, three phase power for stepless motor speed control from 10 percent to 100 percent of the motor's 60 Hz speed. Input voltage shall be 460 volts.

E. **Tests**: The VFD and options shall be tested to ANSI/UL Standard 508. The complete drive, including all specified options, shall be listed by a nationally recognized testing agency such as UL or ETL.

F. **Carrier Frequency**: The VFD out carrier frequency shall be field adjustable from 1 KHz to 12 KHz.

G. **Noise Limitations**: The motor noise as a result of the VFD shall be limited to three db above across the line operation over the audible range of frequencies, measured at three feet from the motor's center line.

H. **Ampacity**: The VFD's full load amp rating shall meet or exceed NEC Table 430-150 for a specified horsepower.

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I. **Protective Features:**

1. Individual motor overload protection for each motor controlled.
2. Protection against input power under-voltage, over-voltage phase loss.
3. Protection against output current overload and instantaneous over-current.
4. Protection against over-temperature within the VFD enclosure.
5. Protection against over-voltage on the DC bus.
6. Protect VFD from sustained power or phase loss. Under-voltage trip activates automatically when line voltage drops more than 10 percent below rated input voltage.
7. Programmable to automatically reset faults due to under-voltage, over-voltage, phase loss or over-temperature.
8. Protection against output short circuit and motor winding shorting to case faults, as defined by UL-508.
9. Status lights or digital display for indication of individual fault conditions.
10. Controller capable of operating without a motor or any other equipment connected to the drive output to facilitate start-up and troubleshooting.
11. VFD shall be programmable for incoming job site power.

J. **Interface Features:**

1. Door mounted Hand/Off/Auto selector switch to start and stop the VFD. In the auto position, the VFD will start/stop from a remote contact closure. In the hand position, the VFD will run regardless of the remote contact position.
2. Manual speed control capability by keypad.
3. Local/Remote selector switch. In the remote position, motor speed is determined by the follower signal. In the local position, motor speed is determined by the manual speed control.
4. Power/on light to indicate that the VFD is receiving utility power.
5. Fault light to indicate that the VFD has tripped on a fault condition.
6. Digital meter with selector switch to indicate percent speed, percent load, and output amps.
7. A set of form-C, dry contacts to indicate when the VFD is in the run mode.
8. A set of form-C, dry contacts to indicate when the VFD is in the fault mode.
9. A 4 to 20 mA or 0 to 10 Vdc output signal to vary in direct proportion to the controller's speed.
10. VFD to have terminal strip to accept N.C. safety contacts such as freezestats, smoke alarms, etc.

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11. VFD to accept an additional N.C. contact to interface with the Hand/Off/Auto switch for remote Stop/Start control.

12. VFD shall accept a 4 to 20 Ma, 0 to 5 Vdc, or 0 to 10 Vdc grounded or ungrounded signal.

K. **Adjustments:**

1. Maximum speed, adjustable 0 to 100 percent base speed.

2. Minimum speed, adjustable 0 to 100 percent base speed.

3. Acceleration, time, adjustable 3 to 180 seconds.

4. Deceleration time, adjustable 3 to 180 seconds with override circuit to prevent nuisance trips if deceleration time is set to short.

5. Current limit, adjustable 0 to 150 percent.

6. Overload trip set point.

7. Offset and gain to condition the input speed signal.

L. **Service Conditions:**

1. Ambient temperature, 32 to 104 degrees F (0 to 40 degrees C).
2. 0 to 95 percent relative humidity, non-condensing.
3. Elevation to 3,300 feet (1,000 meters) with derating.
4. AC line voltage variation, -10 to +10 percent of normal job site conditions.

PART 3 - EXECUTION

3.01 EXAMINATION

A. **Verification of Conditions:** Contractor shall verify that jobsite conditions for installation meet factory recommended and code required conditions for VFD installation prior to start-up. These shall include as a minimum:

1. Clearance spacing

2. Temperature, contamination, dust, and moisture of the environment

3. Separate conduit installation of the motor wiring, power wiring, and control wiring

4. Installation per the manufacturer's recommendations

B. **Equipment Protection:** The VFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.

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3.02 INSTALLATION

A. **Power:** Electrical Contractor shall make a single, 208 volt, 3 phase, 60 Hertz connection for each VFD to a power source and from each VFD to its respective motor.

1. Contractor shall make provisions for Temperature Control Contractor to furnish, install and connect an electronic sensor/controller to control the VFD output.

2. Contractor shall coordinate all wiring with the Electrical Contractor to insure that all input power, output power, and control wiring are in separate conduits for each VFD.

B. **Control:** Transformers, transducers, and voltage/phase reducing devices shall be incorporated in the variable frequency drive motor control NEMA 1 panel.

C. **Panel Location:** Variable frequency drive motor control NEMA 1 panel shall be free standing or surface mounted as shown on Drawings. Panel location shall be coordinated with the Electrical Contractor to meet the requirements of NEC and Local Codes for motor service.

3.03 START-UP SERVICE

A. **Commissioning:** The manufacturer shall provide start-up commissioning of the variable frequency drive and its optional circuits by a factory certified service technician who is experienced in start-up and repair services.

1. The commissioning personnel shall be the same personnel that will provide the factory service and warranty repairs at the customer's site.

   a. Only factory certified technicians for drive field repair shall be acceptable as commissioning agents.

B. **Start-Up:** Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the EMCS. Included in this service, as a minimum, shall be:

1. Verification of Contractor wire terminations to the VFD and its optional circuitry.

2. Installation verification and coordination with the related Contractors for proper operation and reliability of the VFD, the motor being driven, and the EMCS.

3. Up to one hour of customer operator training on operation and service diagnostics at the time of the equipment commissioning.

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4. Measurement for verification of proper operation on each of the following items:

   a. Motor voltage and frequency. Verification of proper motor operation.

   b. Control input for proper EMCS interface and control calibration.

   c. Calibration check for the following set points and adjustments:

      1) Minimum speed
      2) Maximum speed
      3) Acceleration and deceleration rates

   d. Vendor shall file a report to Architect/Engineer verifying conformance with paragraph above in Part 2 in reference to Total Harmonic Distortion.

3.04 WARRANTY

A. **Description:** The VFD shall be warranted by the manufacturer for a period of 24 months from the date of start-up. The warranty shall include parts, labor, travel costs and living expenses incurred by the manufacturer to provide authorized on-site service.

1. The motor(s) which are directly connected to the VFD shall be warranted by the VFD manufacturer against insulation breakdown which is directly attributed to the VFD. The length of the motor insulation warranty shall be the same as the VFD warranty.

   a. If a motor has been driven by another VFD, it shall void this portion of the warranty.

3.05 VARIABLE FREQUENCY DRIVE SCHEDULE

A. Refer to Drawings for Schedules.

END OF SECTION

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EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories necessary to furnish and install expansion fittings and loops applicable to chilled water and heating hot water piping systems.

B. **Related Sections:**

1.	Section 23 00 00:	Heating, Ventilating, and Air-Conditioning (HVAC) - General Requirements
2.	Section 23 05 29:	Hangers and Supports for HVAC Piping and Equipment
3.	Section 23 21 13.23:	Aboveground Hydronic Piping

1.02 SUBMITTALS

A. **Shop Drawings:** Submit a portfolio showing piping specialties for approval by Architect/ Engineer.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers for Expansion Loops - Hydronic Piping:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Flexicraft
2. Metraflex
3. Flexweld
4. Keflex

2.02 PIPING SPECIALTIES

A. **Expansion Loops - Hydronic Piping:** Expansion loops in hydronic supply and return piping, 3 inches or larger, shall be Metraflex Metraloop, or approved equal, flexible hose expansion loop and 150 pound ASA steel, flanges. Expansion loops may be used in lieu of joints where space permits.

1. Provide flexible hose expansion loop(s) as indicated on the contract drawings or as required to accommodate any thermal expansion, contraction or seismic movement of the piping system.

2. Flexible hose expansion loops shall be manufactured complete with two parallel sections of corrugated metal house, compatible braid, 180 deg return bend, with inlet and outlet connections. Field fabricated loops shall not be acceptable.

3. Flexible loops shall be capable of movement in the $\pm X$, $\pm Y$, and $\pm Z$ planes.

4. Flexible hose expansion loops shall impart no thrust loads to system support, anchors or building structure.

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5. Corrugated Hose:

   a. Stainless Steel, B.1.1 Type 304, B.1.2 Type 321, B.1.3 Type 316, 2.1.1 Bronze

6. Braid:

   a. 304 Stainless Steel braid shall be used for any Series 300 stainless steel hose.

   b. Bronze braid shall be used for any bronze hose.

7. Fittings Materials of construction and end fitting type shall be consistent with pipe material and equipment/ pipe connection fittings. Copper fittings shall not be attached to stainless steel hose.

8. Flexible hose expansion loops shall have a factory supplied, hanger / support lug located at the bottom of the 180deg return.

9. Flexible hose expansion loop(s) shall be furnished with a plugged FPT to be used for a drain or air release vent.

Loop Size	FPT Size
1" - 6"	3/8"
8" and Larger	1/2"

10. Flexible hose expansion loop(s) shall be rated with an operating pressure in accordance with the table below. The operating pressure shall be based on burst pressure with a 4 to 1 safety factor.

11. Flexible Expansion Loop with Stainless Steel Hose:

Working Pressure at 70° F. Size	Single Braid	Working Pressure at 70° F. Size	Double Braid
1/2"	1100 PSI	1525	PSI
3/4"	792	1267	
1"	571	914	
1 1/4"	531	850	
1 1/2"	472	755	
2"	500	750	
2 1/2"	387	600	
3"	288	431	
4"	232	371	
5"	200	245	
6"	170	300	
8"	212	260	
10"	175	220	
12"	160	220	

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12. Flexible Expansion Loop with Bronze Hose:

Size	Working Pressure at 70° F. Single Braid	Working Pressure at 70° F. Double Braid	Size
1/2"	566 PSI	753 PSI	
3/4"	468	622	
1"	334	444	
1 1/4"	306	407	
1 1/2"	297	395	
2"	210	279	
2 1/2"	194	258	
3"	166	221	
4"	109	175	

PART 3 - EXECUTION

3.01 INSTALLATION

A. **Expansion Loops:** Install expansion loops centered between anchors (every 70 feet of straight pipe), or where called for on Drawings. Loops shall be of size shown, joints shall match pipe size. Install and guide per manufacturers' installation instructions and Mechanical Contractors Association of America "Guidelines for Quality Piping Installations".

1. Flexible hose expansion loop return fitting shall be supported to allow movement.

2. For steam applications, the operating pressure shall be based on burst pressure with an 8 to 1 safety factor.

END OF SECTION

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SECTION 23 05 19

METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories necessary to furnish and install meters and gauges applicable to heating hot water piping systems.

B. **Related Sections:**

1.	Section 23 00 00:	Heating, Ventilating, and Air-Conditioning (HVAC) - General Requirements
2.	Section 23 21 13.23:	Aboveground Hydronic Piping

1.02 SUBMITTALS

A. **Shop Drawings:** Submit a portfolio showing piping specialties for approval by Architect/ Engineer.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers for Gauges:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. U.S. Gauge Company, Figure 35801
2. Trerice
3. Weksler
4. Weiss

B. **Thermometers:** Thermometers shall be Albert A. Weiss & Son, Inc. or approved equal, red reading, mercury type with range suitable for intended service.

1. Trerice
2. Weksler
3. Weiss

2.02 PIPING SPECIALTIES

A. **Thermometers:**

1. Thermometers shall be 9 inch scale case, industrial type, with vari-angle feature and brass separable socket. Provide extension neck as required on insulated pipe.

   a. In accordance with the following range:

      1) Hot Water: 30 degrees F to 240 degrees F with 2-degree F scale divisions (0 degrees C to 115 degrees C with 1-degree C scale divisions).

      2) Chilled Water: 30 degrees F to 120 degrees F with 2-degree F scale divisions (0 degrees C to 50 degrees C with 1-degree C scale divisions).

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2. Remote reading dial thermometers shall be U.S. Gauge Company, Figure 39001, or approved equal, 4 1/2 inch dial size, cast aluminum back flanged case, bronze spiral armored capillary, with separable socket connection.

   a. In accordance with the following range:

      1) Hot Water: 30 degrees F to 240 degrees F with 2-degree F scale divisions (0 degrees C to 115 degrees C with 1-degree C scale divisions).

      2) Chilled Water: 30 degrees F to 120 degrees F with 2-degree F scale divisions (0 degrees C to 50 degrees C with 1-degree C scale divisions).

B. **Gauges:** Gauges shall be U.S. Gauge Company, Figure 35801, or approved equal, 4 1/2 inch dial size, cast aluminum back flanged case, complete with "T" handle gauge cock. Provide coil siphon on steam line gauges. Provide ray snubbers downstream of gauge cock in pulled circulating lines at each gauge. Label gauge behind glass on face of dial indicating unit of measurement, including psig and feet of head.

   1. In accordance with the following range:

      a. Water: 0 to 100 psi
      b. Steam: 0 to 200 psi

C. **Pressure - Temperature Test Stations:** Provide "Pete's Plug", or approved equal, 1/4 inch MPT fitting to receive either a temperature or pressure probe 1/8 inch outside diameter. Fitting shall be solid brass with valve core of Nordel (maximum 275 degrees), fitted with a color coded and marked cap with gasket; rated at 1,000 psig.

   1. In addition, Contractor shall supply Owner with (4) pressure gauge adapters with 1/8 inch outside diameter probe and (4) 5 inch stem pocket testing thermometers; 25 to 125 degrees F for chilled and condenser water, and (4) 50 to 500 degrees F for hot water.

PART 3 - EXECUTION

3.01 INSTALLATION

A. **Thermometers:** Install thermometers in heating water and chilled water supply and return lines in Boiler Room and Mechanical Rooms before shut-off valves to heating and cooling apparatus.

   1. Mount thermometers for convenient reading of operator standing on floor.

B. **Pressure Gauges:** Install pressure gauge downstream of water meter, at pump header, and elsewhere as indicated on Drawings.

   1. Mount gauges for convenient reading of operator standing on floor.

END OF SECTION

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GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories necessary to furnish and install valves indicated on Drawings and specified.

B. **Related Sections:**

1.	Section 23 00 00:	Heating, Ventilating, and Air-Conditioning (HVAC) - General Requirements
2.	Section 23 01 00:	Operation and Maintenance of HVAC Systems
3.	Section 23 21 13.23:	Aboveground Hydronic Piping
4.	Section 23 25 00:	HVAC Water Treatment

1.02 REFERENCES

A. **American Society of Testing and Materials (ASTM)**

B. **American Society of Mechanical Engineers (ASME):**

1. ASME B16.34: Valves - Flanged, Threaded and Welded End.

1.03 SUBMITTALS

A. **Shop Drawings:** Contractor shall submit a Shop Drawing portfolio showing valves, cocks, to be used and a schedule of equipment and areas to be served for approval by Architect/Engineer.

1.04 QUALITY ASSURANCE

A. **Regulatory Requirements:**

1. State Building Code
2. Plumbing Code
3. Local Codes and Ordinances
4. Local Authority having jurisdiction

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PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers for Globe Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Stockham
2. Powell
3. Hammond
4. Milwaukee
5. Mueller
6. Watts

B. **Acceptable Manufacturers for Check Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Stockham
2. American
3. Powell
4. Hammond
5. Milwaukee
6. Mueller
7. Watts

C. **Acceptable Manufacturers for Non-Slam Check Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Stockham
2. American
3. Powell
4. Hammond
5. Milwaukee
6. Mueller
7. Watts

D. **Acceptable Manufacturers for Angle Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Stockham
2. American
3. Powell
4. Hammond
5. Milwaukee
6. Mueller
7. Watts

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E. **Acceptable Manufacturers for Full Port Ball Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Apollo
2. American
3. Gemini
4. Powell
5. Grinnell
6. Hammond
7. Milwaukee
8. Watts
9. Stockham
10. Bray

F. **Acceptable Manufacturers for Plug Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. American
2. Powell
3. Hammond
4. Milwaukee
5. Mueller
6. Watts

G. **Acceptable Manufacturers for Butterfly Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Stockham
2. Grinnell
3. Milwaukee
4. Watts
5. Bray

2.02 MATERIALS

1. Globe Valves:

   a. 2 Inches and Smaller:

      1) Stockham Figure B-16, 125 Pound Screw Ends

   b. 2 1/2 Inches and Larger:

      1) Stockham Figure G-512, 125 Pound Flanged Ends

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2. Check Valves:
    a. 2 Inches and Smaller:
        1) Stockham Figure B-319, 125 Pound Swing Check Screw Ends
    b. 2 1/2 Inches and Larger:
        1) Stockham Figure G-931, 125 Pound Swing Check Flanged Ends
3. Non-Slam Check Valves:
    a. 2 Inches and Smaller:
        1) Stockham Figure B-326, 400 Pound W.O.G. Threaded End
    b. 2 1/2 Inches and Larger:
        1) Centerline Figure CLC, 150 Pound Spring Check Flanged End Butterfly
4. Angle Valves:
    a. 2 Inches and Smaller:
        1) Stockham Figure B-216, 125 Pound Screw Ends
    b. 2 1/2 Inches and Larger:
        1) Stockham Figure G-515, 125 Pound Flanged Ends
5. Plug Valves:
    a. 3 Inches and Smaller:
        1) ACF Figure D-125, 200 Pound Lubricated Screw Ends
    b. 4 Inches and Larger:
        1) ACF Figure D-126, 200 Pound Lubricated Flanged Ends
6. Full Port Ball Valves:
    a. 2 Inches and Smaller:
        1) Apollo Series 77, Full Port, 600 Pound W.O.G., Soldered or Threaded
    b. 2 1/2 Inches:
        1) Apollo Series 77, Full Port, 600 Pound W.O.G., Threaded

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c. 2 1/2 Inches Through 6 Inches:

1) Apollo Series 88-200, Full Port, Class 150, Flanged

d. 8 Inches Through 12 Inches:

1) Apollo Series 88-200, Full Port, Gear Driven, Class 150, Flanged

e. Ball valves in insulated piping shall have 1-1/4 inch extended stems.

B. **Butterfly Valves**: Butterfly valves may be used only in systems where operating temperatures do not exceed 200 degrees F, after obtaining written permission of the Architect/Engineer for each specific location. Seat material shall be EPDM. Valve bodies shall be of high grade cast iron with extended neck to accommodate pipe insulation and shall be of lug body design using cap screws to provide end-of-line service. Discs shall be of aluminum bronze construction with no external fasteners. Stems shall be of 316 stainless steel, 2-piece type, with infinitely adjustable, corrosion resistant throttling handle with memory stop. Valves 2 inches to 6 inches shall have throttling levers; 8 inches and larger shall utilize worm gear operators.

C. **Check Valves**: Check valves in chilled and cooling tower water piping may be Demco Type K-F, silent non-slam rated for 150 pound service with 316 stainless steel internal operating parts and Teflon bushings.

D. **Drain Valves**: Locate where shown on Drawings and at all low points in system; Apollo Series 78-100/200 with hose thread, cap and chain, 600-pound W.O.G., soldered or threaded, in accessible location for easy draining of heating and chilled water system.

E. **Valve Tags**: Valves shall be provided with Seton No. 250BL, 1 1/2 inch round valve tag with a 36 nickel plated bead chain. Stamp tags with description of equipment, piping or fixtures served and valve numbers. Provide a typewritten list identifying all numbered valves and submit with operation and maintenance manual (See Appendix 'A' at the end of this section for sample and blank form).(For remodel and additions, contractor shall coordinate valve tagging with owners existing tagging procedures and logs).

PART 3 - EXECUTION

3.01 INSTALLATION

A. **General Requirements**: Furnish and install full port ball, globe, and check valves where indicated on Drawings and where necessary for proper control of piping and equipment. Valves shall be same size as pipe in which installed, unless otherwise specified or shown on Drawings.

1. Full port ball valves shall be used where shut-off valves are to be fully open or closed.

2. Globe, full port ball, and angle valves shall be used where flow is to be throttled.

3. Valves on chromium plated piping shall be polished brass finish chromium plated. Compression stops shall be heavy pattern with stuffing box.

4. Valves shall be of one manufacturer and shall have name or trademark cast or stamped on valve.

a. Valves shall have packing gland nut, packing and back seating design.

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B. **Accessibility/Operation:**

1. Valves shall be installed to be easily accessible for operation, visual inspection, and preventive maintenance.

2. Unless otherwise noted, valves shall be installed with valve stem in vertical position above piping, except chain-operated valves.

3. Valves with stem above 8 feet from floor in boiler or equipment rooms shall have chain wheel operator and chain with chain guard.

C. **Butterfly and Ball Valve Substitution:**

1. Globe valves 4 inches and larger may be replaced with butterfly valves.

2. Globe valves 3 inches and smaller may be replaced with ball valves.

(Refer to Following Page for Valve Tag Schedule)

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Appendix 'A'

VALVE TAG SCHEDULE							
VALVE TAG	LOCATION	TYPE	SIZE	FUNCTION	SYSTEM	MATERIAL	REMARKS
VALVE #1	C119	BALL	3/4"	SHUT-OFF	DOMESTIC	BRONZE	THIS IS AN EXAMPLE.
VALVE #2	G138	GLOBE	2"	DRAIN	HEATING	IRON	THIS IS AN EXAMPLE.

END OF SECTION

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HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories to furnish and install supports, anchors, and seals for equipment, materials, and related work specified elsewhere.

B. **Related Sections:**

1.	Section 23 00 00:	Heating, Ventilating, and Air-Conditioning (HVAC) - General Requirements
2.	Section 23 21 13.23:	Aboveground Hydronic Piping
3.	Section 23 23 00:	Refrigerant Piping
4.	Section 23 31 13:	Metal Ducts

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers for Guides:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Metraflex
2. Hyspan
3. Flexweld
4. Keflex
5. Flexicraft
6. Flexonic

2.02 DUCTWORK INSERTS AND HANGERS

A. **General:** Support ductwork by concrete inserts in concrete construction, "C" clamps for beams and bar joists, or toggle bolts on prefabricated reinforced hollow concrete slabs. When ductwork is hung from beams or joist, the attachment shall be made to the top of the beam or joist.

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B. **Rectangular Ductwork:** From any of these structure connection supports, provide hanger straps or hanger rod with supporting angle iron below rectangular ductwork:

LONGEST DIMENSION OF DUCT (INCHES)	ROD HANGERS	STRAP HANGERS	TRAPEZE SHELF ANGLES (INCHES)	MAXIMUM SPACING
Up Through 18		1 Inch X 16 Gauge (2 Hangers; Minimum 2 Screws)	1 X 1 X 1/8	10 Feet
19 Through 30		1 Inch X 16 Gauge (2 Hangers; inimum 2 Screws)	1 X 1 X 1/8	10 Feet
31 Through 42	1/4 Inch Rod	1 Inch X 16 Gauge (Minimum 3 Screws With Turn Under)	1-1/2 X 1-1/2 X 1/8	10 Feet
43 Through 60	3/8 Inch Rod		1-1/2 X 1-1/2 X 1/8	10 Feet
61 Through 84	3/8 Inch Rod		2 X 2 X 1/8	8 Feet
85 Through 96	3/8 Inch Rod		2 X 2 X 3/16	8 Feet
Over 97	3/8 Inch Rod		2 X 2 X 1/4	8 Feet

C. **Round Ductwork:** From any of these structure connection supports, provide hanger straps or hanger rod with supporting angle iron below round ductwork:

DUCT DIAMETER	ROD HANGERS	STRAP HANGERS	MAXIMUM SPACING	NUMBER OF HANGERS
Up Through 18	3/8 Inch Rod	1 Inch X 16 Gauge	10 Feet	1
19 Through 36	3/8 Inch Rod	1 Inch X 12 Gauge	10 Feet	1
37 Through 50	(2) 3/8 Inch Rod	2 Inch X 20 Gauge	10 Feet	1
51 Through 84	(2) 3/8 Inch Rod	2 Inch X 16 Gauge	10 Feet	1

D. **Support:**

1. Provide bridging between structural members, as required, to provide adequate support locations for hangers.

2. Ductwork shall not be supported from metal roof decking.

3. Ductwork, piping or conduits shall not be supported from non-structural members, cross bridging, etc.

2.03 SPECIAL APPLICATIONS

A. **Tunnels and Crawl Spaces:** Materials for inserts, rods and hangers in tunnels and crawl spaces shall be of non-ferrous material. Unistrut steel products shall have prime bonderized finish coating. Contractor shall field coat any raw cut edges on steel products with a prime bonderized finish coating.

2.04 PIPING INSERTS AND HANGERS

A. **General Requirements:** Hangers and anchors for piping shall be attached to the building construction. Piping shall not be supported from another pipe.

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B. **Hanger Supports and Inserts:** Piping suspended from the building construction above shall be hung from concrete inserts in concrete construction, toggle bolts and rod coupling on prefabricated, reinforced hollow concrete slabs, I-beam clamps or hanger rod, steel washer plate and two nuts on bar joist construction. On other types of building construction a field approved type clamp or bracket shall be used. When piping is hung from beams or joist, the attachment shall be made to the top of the beam or joist.

C. **Hangers, Clamps, and Collars:** Piping shall be suspended from inserts, clamps or brackets by means of clevis type or roller type hanger and solid steel rods. Support vertical cast iron and steel pipes at each floor by heavy wrought steel riser clamps or collars. Support vertical copper pipes at each floor by riser clamps with asphalt felt lining under couplings placed in vertical copper piping. Support piping 4 inches and larger for hot water heating systems by single pipe roller assemblies with adjustable socket.

D. **Piping:** Horizontal piping shall be supported at intervals close enough to keep it in alignment and to prevent sagging.

PIPING SUPPORT SPACING

Pipe Diameter	Rod Hangers	Maximum Horizontal Spacing	Maximum Vertical Spacing
Copper or Copper-Alloy Pipe 1-1/4 Inch and Smaller	3/8 Inch Rod	6 Feet	10 Feet
Copper or Copper-Alloy Pipe 1-1/2 Inch and Larger	3/8 Inch Rod	10 Feet	10 Feet
Copper or Copper-Alloy Tubing 1-1/4 Inch and Smaller	3/8 Inch Rod	6 Feet	10 Feet
Copper or Copper-Alloy Tubing 1-1/2 Inch and Larger	3/8 Inch Rod	10 Feet	10 Feet
CPVC Pipe or Tubing, 1 Inch and Smaller	3/8 Inch Rod	32 Inches	10 Feet **
CPVC Pipe or Tubing, 1-1/4 Inch and Larger	3/8 Inch Rod	32 Inches	10 Feet **
Polypropylene Pipe	3/8 Inch Rod	32 Inches	10 Feet **
Polyvinylidene Fluoride Pipe	3/8 Inch Rod	32 Inches	10 Feet **
PVC Pipe	3/8 Inch Rod	32 Inches	10 Feet **
Steel Pipe, Schedule 40, 1 Inch and Smaller	3/8 Inch Rod	6 Feet	15 Feet
Steel Pipe, Schedule 40, 1-1/4 Inch to 2 Inch	3/8 Inch Rod	10 Feet	15 Feet
Steel Pipe, Schedule 40, 2-1/2 Inch to 3 Inch	1/2 Inch Rod	12 Feet	15 Feet
Steel Pipe, Schedule 40, 4 to 6 Inch	5/8 Inch Rod	12 Feet	15 Feet
Steel Pipe, Schedule 40, 8 Inch and Larger	7/8 Inch Rod	12 Feet	15 Feet
Steel Tubing	3/8 Inch Rod	8 Feet	10 Feet
Exposed Vertical Plastic Piping	3/8 Inch Rod	—	4 Feet

* WHERE 10 FOOT LENGTHS OF CAST-IRON PIPE ARE USED, TEN FOOT INTERVALS BETWEEN SUPPORTS ARE ACCEPTABLE.
** PROVIDE MID-STORY GUIDE.

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E. **Piping:** Vertical piping shall be secured at intervals close enough to keep it in alignment.

1. Copper Tubing, at each story.

2. Threaded Steel Pipe, every other story height.

3. Steel Pipe with Grooved End Fittings, anchor at each floor level.

2.05 ANCHORS AND GUIDES

A. **Anchor Fabrication:** Construct anchors using I-beams, channel iron, tees, or angles or a combination thereof.

1. Tee iron shall be welded to side, top or bottom of pipe. Angle iron diagonal bracing shall be welded or bolted to tee iron and wall or ceiling. Anchors shall be welded or double clamped to pipe.

2. Where a group of pipes are to be anchored, but cannot be secured as above, the pipes shall be anchored to an assembly constructed of I-beams, channels or both, which shall be anchored to the building structure.

B. **Guides:** Guides shall be fabricated from carbon steel. Housing shall be of two piece design, connecting upper and lower housing with two bolt or by welding, after spider and pipe have been set in lower half of housing. Lower housing shall have two legs for support running the full length of housing. Two piece spider clamp shall be fastened around pipe (or pipe with insulation) with two bolts forming six legs which guide pipe inside housing. Legs may be on bottom, side or top of unit for bolting to floor or top of beam, wall or underside of structure.

1. Insulation inside the spider clamp shall be hydrous calcium chloride with vapor barrier from entering and exiting pipe continuing through the clamp.

2. Unit shall be furnished with a factory baked enamel finish.

PART 3 - EXECUTION

3.01 HANGER INSTALLATION

A. **Hanger Location:** Locate hangers to properly support pipes and ducts; relieve strain on pipe, duct, and fittings; and allow for ample expansion and contraction. Piping smaller than 4 inch size shall be hung with individual ring hangers where space prevents use of other type hangers.

1. Piping or ductwork shall not be hung from the roof deck.

2. Insulation sheet metal shields shall be placed between insulation and pipe hangers at all hangers.

B. **Trapeze Hangers:** Groups of pipes at the same elevation and close together may, at the option of the Contractor, be supported by suitable trapeze hangers suspended from inserts, clamps or brackets by solid steel rods. Provide single pipe roller assemblies as indicated in Part 2 of this Specification.

C. **Plastic Piping Support:** Support plastic piping from above inserts, clamps or brackets with Grinnell Figure 269 adjustable ring hanger on 32 inch centers.

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3.02 BRACKETS, BRACES, AND SUPPORTS

A. **General Requirements:** Furnish and install brackets, braces or reinforcing angles in partitions not sufficient in themselves to support piping or other wall hung equipment included in this Specification. Bolts shall extend through walls, finished on opposite side, or one wall of a pipe chase, and shall be not less than 3/8 inch brass bolts with 3 inch cut washer on opposite side of wall.

B. **Fasteners:** Bolt head and washer shall be concealed under wall finish on finished walls. On hollow walls not finished on opposite sides, use toggle bolts. On solid walls use 3/8 inch brass bolt extending 4 inches into wall secured with molten lead poured around bolt. Secure floor mounted wall closets with 5/16 inch brass bolt with chrome plated cap, nut, and washer.

C. **Support Racks:** Support tunnel piping on Unistrut, Bee-Line or approved equal, pipe racks assembled as indicated by details on Drawings. Unistrut steel products shall have prime bonderized finish coating. Contractor shall field coat any raw cut edges on steel products with a prime bonderized finish coating.

D. **Pipe Drop Supports:** Brace exposed pipe drops to pumps and other equipment with angle iron framework to relieve strain on flexible connectors or equipment and anchor piping to eliminate movement.

3.03 INSTALLATION OF ANCHORS AND GUIDES

A. **Boiler Room:** Provide adequate anchors and guides on heating piping in Mechanical Rooms and Boiler Room to prevent swaying of pipe.

B. **Anchors:** Install anchors approximately centered in every 70 foot run, blind ends, changes in pipe direction, except when elbow is used to absorb expansion and at major branch connections.

1. An expansion joint or loop or expansion elbow, but not more than one, with appropriate guides, shall be installed between each pair of anchors.

2. If expansion loops are installed in same line with expansion joints, the section containing the loop shall be isolated from the section containing the joint by means of an anchor.

C. **Guides:** Install 4 guides, 2 on each side, for each expansion loop or joint. On each side, install one pipe guide a maximum of 4 pipe diameters from expansion loop or joint and one pipe guide a maximum of 14 diameters from the first guide.

D. **Anchors and Guides in Radiation Covers:** Provide anchors and guides in radiation covers where called for on Drawings and specified. Provide guides at each side of expansion joints.

END OF SECTION

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SECTION 23 05 30

HYDRONIC SYSTEM SPECIALTIES

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories necessary to furnish and install hydronic specialties in relation to hydronic supplied equipment specified in Section 23 21 13.23 - Aboveground Hydronic Piping.

B. **Related Sections:**

1.	Section 23 00 00:	Heating, Ventilating, and Air-Conditioning (HVAC) - General Requirements
2.	Section 23 01 00:	Operation and Maintenance of HVAC Systems
3.	Section 23 05 13:	Common Motor Requirements for HVAC Equipment
4.	Section 23 05 53:	Identification for HVAC Piping and Equipment
5.	Section 23 21 13.23:	Aboveground Hydronic Piping
6.	Section 23 25 00:	HVAC Water Treatment

1.02 REFERENCES

A. **American Society of Mechanical Engineers (ASME)**

1.03 SUBMITTALS

A. **Shop Drawings:** Submit a portfolio showing hydronic system specialties to be used and a schedule of equipment to be served with related specialty types and sizes for approval by Architect/Engineer.

1.04 QUALITY ASSURANCE

A. **Regulatory Requirements:**

1. State Building Code

2. Local Codes and Ordinances

3. Local Authority having jurisdiction

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers for Strainers:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Crane No. 988-1/2 or Crane No. 989-1/2
2. Metraflex
3. Mueller

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B. **Acceptable Manufacturers for Flexible Pump Connectors:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Metraflex
2. Minnesota Flexible
3. Flexonics
4. ThermoTech
5. Mason Industries
6. Tri-State Industries

C. **Acceptable Manufacturers for Flow Indicators:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Bell & Gossett
2. Ken Gerrish Company

D. **Acceptable Manufacturers for Balance Valves:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Ken Gerrish Company
2. Bell & Gossett
3. Tour Anderson
4. Nexus

2.02 PIPING SPECIALTIES

A. **Unions - Hydronic Piping:** Flanged union connections shall be made with 150 psi weld neck flanges, with not less than 1/16 inch sheet gasket. Screwed unions shall be Crane No. 250-H or approved equal, bronze to steel seat, 2,000 psi.

B. **Strainers:** Strainers shall be Crane No. 988-1/2, Crane No. 989-1/2, or Engineer approved equal, with stainless steel or monel mesh screen with reinforced ends and 2 inch pipe nipple with blow-off valve and cap on discharge openings.

1. Provide 20 mesh size for 1-1/2 inch and less and 40 mesh size for 2 inch and larger.

C. **Air Vents:**

1. Manual: Crane No. 702 petcock or approved equal or Dole No. 9 coin valve or approved equal.

2. Automatic: Heavy duty unit with built in air chamber, overflow connector for 1/4 inch O.D. copper tubing. Acceptable manufacturers: B&G No. 7, Sarco 13W or approved equal.

D. **Pressure and Temperature Ratings:**

1. Maximum working pressure 125 psi.

2. Maximum operating temperatures 200 degrees F.

E. **Indicator Package:** Provide with indicator package consisting of two (2) ball valves, five (5) pipe nipples, two (2) sightglasses, one (1) annunciator, and one (1) flow control orifice (Note: Provide rigid piping as indicated on the drawing detail sheets). Package will indicate a 15 psi pressure drop.

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2.03 FLOW INDICATORS - (Use at Pumps)

A. **General Requirements**: Fabricate flow indicators of brass with machined, calibrated orifice opening with pressure taps, 1/4 inch valves and quick disconnect fittings.

1. Venturi style indicators may be used in lieu of orifice type. B&G Circuit Sensor Flow Meter or Approved

2.04 BALANCE VALVES

A. Balance valves larger than 4 inches shall be globe or ball style with memory stops and integral flow indicator.

B. Balance valves 4 inches and smaller shall be globe or ball style balance valves with memory stops and integral flow indicators.

C. Contractor may use (balance valve kits) as described above, with integral strainers, vents, drain valves and unions at reheat coils, VAV box coils, fan-coil units, unit ventilators, dedicated energy recovery(vertical unit ventilators) units, and unit heaters.

D. Where flow limiting devices are used, device shall be selected with a design flow rate of 1.0 GPM as a minimum flow through the limiting device. Flow reduction below that point shall be by balancing and valve adjustment.

2.05 FLEXIBLE PUMP CONNECTORS - BRAIDED HOSE

A. **General Requirements - Water Piping:** Flexible stainless steel Type 321 hose and braided cover with carbon steel ends. 2 1/2 inch pipe size and smaller - male nipples. 3 inch pipe size and larger - 150 lb. ASA flanges. Pipe sizes up to and including: 1 1/2 inch pipe - 12 inch long, 3 inch pipe - 18 inch long, 6 inch pipe - 24 inch long, 8 inch pipe and over 36 inches long.

B. **General Requirements - Freon Piping:** Flexible bronze braided hose with copper ends for Freon.

PART 3 - EXECUTION

3.01 INSTALLATION

A. **Location:** Install compression tanks and air separators where shown on Drawings.

B. **Unions - Hydronic:** Install unions or flanges in pipe connections to equipment and where shown on Drawings and details. Install air separators with unions on inlet and outlet.

C. **Strainers:** Install strainers where indicated on Drawings of same size as pipe in which it is installed.

D. **Installation:** Install compression tanks with a tank fitting, a drain valve with hose end connection, and gauge glass.

1. When more than one tank is used, tanks shall be parallel connected at top and bottom, and valved to allow isolation of one while operating the other(s).

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E. **Balancing Valves and/or Automatic Flow Control Valves**: Install balancing valves where indicated on the Drawings, with the flow rates as indicated.

1. Where balancing valves are indicated, auto flow control valves may be substituted.

2. Use globe style balance valves at large pipe location, and air handling equipment. Ball style or globe style balancing valves may be used at terminal equipment.

F. **Flexible Connectors**: Install a flexible connector at each pump outlet. Exercise special care to provide pipe alignment such that no offset from pump to pipe will occur in flexible connector.

1. For braided hose install horizontally, where possible, on the equipment side of shut off valves.

G. **Air Vents**: Provide and install vents where indicated on Drawings and where required in piping installation.

1. Manual Air Vent: Install air vent valves at the high point wherever drops occur in the direction of water flow, at the top of all supply risers and at the high points of return risers on all hydronic supply and return mains. Install air vent valves on the end of 1/8 inch copper tubing extended to an accessible location from a reducer provided at the high point. If not in a accessible location copper lines shall run to a 6 inch by 6 inch electrical box with stainless steel cover and shall terminate with a manual air vent.

a. The high side of heating elements on upfed hot water radiation, hydronic coils, cabinet unit heaters, etc., to be piped complete with a 3/4 inch by 4 inch high air chamber with a reducer at the top from which a 1/8 inch copper tube to be extended to an accessible manual (not automatic) key operated air vent valve.

2. Automatic Air Vent: Install automatic air vents at the top of supply risers and at the high point of return risers of hydronic supply and return mains where indicated. Air vent valve to be preceded by an isolation shut off valve. Extend drain line to an accessible location.

3.02 EQUIPMENT SCHEDULES

A. Refer to Drawings for Schedules.

END OF SECTION

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SECTION 23 05 48

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories to furnish and install vibration isolation equipment for equipment specified in this Contract.

B. **Related Sections:**

1.	Section 23 00 00:	Heating, Ventilating, and Air-Conditioning (HVAC) - General Requirements
2.	Section 23 21 13.23:	Aboveground Hydronic Piping
3.	Section 23 75 13:	Custom-Packaged, Outdoor, Central-Station Air-Handling Units

1.02 SUBMITTALS

A. **Shop Drawings:** Contractor shall submit a Shop Drawing portfolio showing vibration isolators to be used, a schedule indicating units served, and type and number of isolators per unit for approval by Architect/Engineer.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers for Vibration Isolation Equipment:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Mason Industries, Inc.
2. Amber Booth
3. Iso-flex
4. Kinetics
5. Vibration Eliminator Company
6. VMC

2.02 VIBRATION ISOLATION EQUIPMENT

A. **Schedule:** The following schedule of vibration isolation equipment is specified for reference with the type desired for each piece of equipment being noted under the equipment section.

1. Type A: Mason Industries Type C housed spring mounts with neoprene non-skid pad on bottom, minimum static deflection 3/4 inch and 0.8 ratio spring diameter to compressed height.

2. Type B: Mason Industries Type SLFH free spring mounts with leveling adjustment, base plate with bolt holes and a 1 to 1 horizontal-vertical constant, minimum static deflection 1 inch and as called for and 0.8 ratio of spring diameter to compressed height.

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3. Type C: Mason Industries Type N Neoprene-in-shear mounts, non-skid surface top and bottom, minimum static deflection 0.4 inch.

4. Type D: Mason Industries Type ND double deflection mounts, non-skid surface top and bottom, minimum static deflection 0.4 inch.

5. Type E: Mason Industries Type DNHS combination spring and double deflection neoprene hangers, minimum deflection 1.4 inch.

6. Type F: Mason Industries Type HD hanger, double deflection neoprene unit minimum static deflection 0.4 inch.

7. Type G: Mason Industries Type W neoprene pad, 5/16 inch thick, with 50 pounds per square inch maximum loading.

8. Type H: Mason Industries Type NLD structural steel fan and motor base with integral motor slide rail, supported by a double deflection neoprene mount. Structure shall be rigid enough so as to prevent distortion on drive side and eliminate the requirement of vertical snubbers. Minimum static deflection 0.4 inch.

9. Type I: Mason Industries Type SLF structural steel fan and motor base with integral motor slide rail, supported on Type SL bare springs with a 1 to 1 horizontal-vertical constant, structure shall be rigid enough to eliminate the use of any vertical snubbers and prevent drive distortion. Minimum static deflection 1 inch.

10. Type J: Mason Industries Type SLR multiple spring mounts with leveling adjustment, snubbers, base plate with neoprene acoustical isolation pads and 4 bolt holes, hot-dip galvanized and minimum static deflection 3/4 inch and 0.8 ratio spring diameter to compressed height.

11. Type K: Mason Industries Type 30 angularity spring hanger with neoprene seat, minimum deflection 0.8 inch.

B. **Pumps and Motor Bases:**

1. Units on Grade: Mount pumps located on grade on thickened concrete floor slab, top 4 inches above floor with 1/2 inch rubber expansion joint material between floor and perimeter of pump concrete pad. Pump assembly base shall have 5/8 inch thick by 3 inch wide neoprene waffle pad at all points of contact between pump base and concrete.

PART 3 - EXECUTION

3.01 INSTALLATION

A. **Application:** Meet requirements of manufacturer's instructions for installation and load application to vibration isolation materials and units.

1. Adjust to ensure that units do not exceed rated operating deflections or bottom out under loading, an are not short-circuited by other contacts or bearing points.

2. Remove space blocks and similar devices intended for any temporary protection against overloading during installation.

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3. Anchor and attach units to structure and equipment as required for secure operation and to prevent displacement by normal forces.

4. Adjust leveling devices as required to distribute loading uniformly onto isolators.

5. Shim units where leveling devices cannot be used to distribute loading properly.

B. **Motor Isolation:** Install vibration isolators for mechanical motor-driven equipment.

C. **Spring Isolators:**

1. Provide spring isolators on piping connected to isolated equipment as follows:

a. 3 to 4 Inch Diameter: First 3 points of support.

b. 5 to 8 Inch Diameter: First 4 points of support.

c. 10 Inch Diameter and Over: First 6 points of support.

2. Static deflection of first point shall be twice deflection of isolated equipment.

END OF SECTION

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IDENTIFICATION FOR HVAC SYSTEMS AND EQUIPMENT

PART 1 - GENERAL

Not Used

PART 2 - PRODUCTS

2.01 MECHANICAL IDENTIFICATION

A. All pipe markers (purchased or stenciled) shall conform to ANSI A13.1. Hazardous materials (toxic, extreme temperature or pressure etc.) shall have black letters on yellow background. Low hazard liquids shall have white letters on green background. Low hazard gasses shall have white letters on blue background. Letter sizes shall be at least the following:

O.D. OF PIPE OR INSULATION	SIZE OF LETTERS
UP TO 1-1/4 Inch	1/2 Inch
1-1/4 Inch	3/4 Inch
1-1/4 Inch To 2 Inches	1-1/4 Inch
2-1/2 Inch To 10 Inches	2-1/2 Inch
Over 10 Inches	3-1/2 Inch
PLASTIC TAGS MAY BE USED FOR OUTSIDE DIAMETERS UNDER 3/4 Inch	

B. Acceptable Manufacturers shall be W.H. Brady, Seton, or approved equals.

C. **Plastic Nameplates:** Laminated three-layer phenolic with engraved black, 1/4 inch minimum letters on light contrasting background.

D. **Aluminum Nameplates:** Black enamel background with natural aluminum border and engraved letters furnished with two mounting holes and screws.

E. **Plastic Tags:** Minimum 1 1/2 inch square or round laminated three-layer phenolic with engraved, 1/4 inch minimum black letters on light contrasting background.

F. **Bass Tags:** Brass background with engraved black letters. Tag size minimum 1 1/2 inch square or 1 1/2 inch round.

G. **Plastic Pipe Markers:** Semi-rigid plastic, preformed to fit around pipe or pipe covering; indicating flow direction and fluid conveyed.

H. **Vinyl Pipe Markers:** Colored vinyl with permanent pressure sensitive adhesive backing.

I. **Stencil Painted Pipe Markers:** Use industrial enamel spray paint per ANSI Standard A13.1. Indicate fluid conveyed and flow direction.

J. **Underground Pipe Markers:** Bright colored continuously printed plastic ribbon tape 6 Inches wide by 3.5 mils thick, manufactured for direct burial, with aluminum foil core for location by non-ferric metal detectors.

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PART 3 - EXECUTION

3.01 IDENTIFICATION AND LABELING

A. **Exposed and Concealed Piping:** Bare and insulated exposed new piping in Boiler Room, Mechanical Rooms, and unfinished rooms, and bare and insulated new piping running in ceilings and soffits shall be identified with labels. Labels shall include a directional arrow 3 inches long by 1/2 inch wide, indicating direction of flow.

1. Labels shall be clearly visible and located at each change in direction of pipe runs, at each valve, on both sides of walls, partitions, and floors that pieces penetrate, at each riser and each leg of each "T" joint, at least once in every room, and at intervals not to exceed 20 feet.

2. Underground pipe markers shall be installed 8 inch to 10 inch below grade, directly above buried pipes.

B. **Pipe Markers:** Contractor shall label the piping as follows:

PIPE SERVICE	LABEL	LETTERING COLOR	BACKGROUND COLOR
Chiller Water (With Glycol) Return	GCHR	White	Green
Chiller Water (With Glycol) Supply	GCHS	White	Green
Chiller Water (Without Glycol) Return	CHWR	White	Green
Chiller Water (Without Glycol) Supply	CHWS	White	Green
Condensate Drain	CD	Black	Yellow
Heating (With Glycol) Hot Water Return	GHWR	Black	Yellow
Heating (With Glycol) Hot Water Supply	GHWS	Black	Yellow
Heating (Without Glycol) Hot Water Supply	HWS	Black	Yellow
Heating (Without Glycol) Hot Water Return	HWR	Black	Yellow
Low Pressure Steam	LPS	Black	Yellow
Low Pressure Condensate Return	LPR	Black	Yellow

C. **Ductwork:**

1. Exposed Ductwork in Mechanical Equipment Rooms: Ductwork exposed in Boiler Room, and Mechanical Rooms shall be identified with labels indicating direction of air flow and fan number. Label shall have 1 inch high letters and shall include a directional arrow 3 inches long by 1/2 inch wide, indication direction of air flow. Color of stenciling shall be black lettering on a yellow background.

   a. Labels shall be located at each change in direction of ductwork runs and at intervals not to exceed 20 feet.

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D. **Concealed Equipment:**

1. The location of equipment, furnished under this Contract, installed above ceiling shall be identified by placing a clear adhesive label with 1/4 inch black lettering on the ceiling grid directly below item identified. Attached a 1/2 inch red adhesive dot next to the equipment label. Identification shall be as follows:

   a. VAV Boxes (with unit numbers)
   b. Control Valves (with valve numbers)
   c. Shut-Off Valves (with valve numbers)
   d. Temperature Control Controller and Equipment

E. **Equipment:**

1. General: Provide engraved plastic laminated signs on or near each major item of mechanical equipment and at all equipment not easily identifiable such as controls, relays, gauges, etc.; and all equipment in an area remote from its function such as air handling units, exhaust fans, filters, reheat coils, dampers, etc.; shall have tags or nameplates listing name, function, and drawing symbol, fasten tags with stainless steel self-tapping screws or permanently bonding cement.

2. Schedule: Provide signs for the following equipment. Signs shall be a minimum of 1 1/2 inches high with 3/4 inch high lettering:

   a. Air Handling Units, Rooftop Units, Energy Recovery Units, Return/Relief Fans
   b. Exhaust Fans, Power Roof Ventilators
   c. Water Treatment Systems, Humidifiers
   d. Main Control Valves and Safety Equipment
   e. Meters, Variable Speed Drives
   f. Temperature Control Panels

F. **Miscellaneous:**

1. Attach self-adhesive vinyl labels at all duct access doors used to reset fusible links or actuators on fire, fire/smoke, or smoke dampers. Lettering shall be a minimum of 1/2 inch high. Labels shall indicate damper type.

2. All identification and labeling shall be completed before above ceiling inspections will take place.

END OF SECTION

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SECTION 23 05 54

ACCESS PANELS FOR HVAC SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:**

1. Furnish wall and ceiling access doors indicated on Drawings and as indicated in Part 3 of this Specification.

B. **Related Sections:**

1.	Section 23 00 00:	Heating, Ventilating, and Air-Conditioning (HVAC) - General Requirements
2.	Section 23 09 23:	Direct-Digital Control System for HVAC
3.	Section 23 21 13.23:	Aboveground Hydronic Piping
4.	Section 23 23 00:	Refrigerant Piping
5.	Section 23 31 13:	Metal Ducts

1.02 SUBMITTALS

A. **General Requirements:** Provide submittals in accordance with Section 01 33 00.

B. **Product Data:** Submit manufacturer's technical data and installation instructions, including setting drawings, templates, instructions, and directions for installation of anchorage devices.

C. **Shop Drawings:** Submit a Shop Drawing portfolio showing access panels to be used and a schedule of equipment and areas to be served for approval by Architect/Engineer. Include details, elevations, anchorage, and accessory items.

1.03 QUALITY ASSURANCE

A. **Fire Resistance Ratings:** Wherever a fire resistance classification is indicated, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in Underwriters' Laboratories, Inc., "Classified Building Materials Index" for rating shown.

B. **Identification of Fire Rating:** Provide Underwriters' Laboratories label on each fire rated access door.

C. **Size Variations:** Obtain Architect's acceptance of manufacturer's standard size units which may vary slightly from sizes indicated on Drawings.

D. **Coordination:** Furnish inserts and anchoring devices which shall be built into other work for installation of access doors. Coordinate delivery with other work to avoid delay.

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PART 2 - PRODUCTS

2.01 FLUSH PANEL WALL ACCESS DOOR

A. **Acceptable Manufacturers**: Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milcor Limited Partnership, Lima, Ohio; "Style M"

B. **Fabrication**:

1. Sizes: 24 inches by 24 inches for gypsum wall board or plaster surfaces and 16 inches by 16 inches for masonry surfaces.

2. Frame Material: 16 gauge steel.

3. Door Panel Material and Construction: 20 gauge steel.

4. Finish: Chemically bonded prime coat of baked enamel over a protective phosphate coating on the steel.

5. Hinge: Concealed spring hinges or continuous piano hinge with removable pins.

6. Locking Device: Key operated cylinder lock with 2 keys. Coordinate with owner to insure that all access panels for project operate by same key.

7. Anchors: Provide appropriate anchors for adjacent construction.

2.02 FLUSH PANEL FIRE RATED WALL ACCESS DOOR

A. **Acceptable Manufacturers**: Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milcor Limited Partnership, Lima, Ohio; "Style UFR"

B. **Fire Rating**: Access door shall carry Underwriters' Laboratories 1 1/2 hour "B" Label rating.

C. **Fabrication**:

1. Sizes: 24 inches by 24 inches for gypsum wall board or plaster surfaces and 16 inches by 16 inches for masonry surfaces.

2. Frame Material: 16 gauge steel.

3. Door Panel Material and Construction: 20 gauge steel.

4. Finish: Chemically bonded prime coat of baked enamel over a protective phosphate coating on the steel.

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5. Hinge: Concealed spring hinges or continuous piano hinge with removable pins.

6. Locking Device: Key operated cylinder lock with 2 keys. Coordinate with owner to insure that all access panels for project operate by same key.

7. Anchors: Provide appropriate anchors for adjacent construction.

2.03 FLUSH PANEL PLASTER CEILING ACCESS DOOR

A. **Acceptable Manufacturers**: Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milcor Limited Partnership, Melrose Park, IL; Style K

B. **Fabrication:**

1. Sizes: 24 inches by 24 inches, 24 inches by 36 inches, 30 inches by 36 inches, or 36 inches by 48 inches, for plaster surfaces.

2. Frame Material: 16 gauge steel.

3. Door Panel Material and Construction: 14 gauge steel.

4. Finish: Chemically bonded prime coat of baked enamel over a protective phosphate coating on the steel.

5. Hinge: Concealed spring hinges or continuous piano hinge with removable pins.

6. Locking Device: Key operated cylinder lock with 2 keys. Coordinate with owner to insure that all access panels for project operate by same key.

7. Anchors: Provide appropriate anchors for adjacent construction.

2.04 FLUSH PANEL DRYWALL CEILING ACCESS DOOR

A. **Acceptable Manufacturers**: Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Milcor Limited Partnership, Melrose Park, IL; Style DW

B. **Fabrication:**

1. Sizes: 24 inches by 24 inches for drywall board surfaces.

2. Frame Material: 16 gauge steel.

3. Door Panel Material and Construction: 14 gauge steel.

4. Finish: Chemically bonded prime coat of baked enamel over a protective phosphate coating on the steel.

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5. Hinge: Concealed spring hinges or continuous piano hinge with removable pins.

6. Locking Device: Key operated cylinder lock with 2 keys. Coordinate with owner to insure that all access panels for project operate by same key.

7. Anchors: Provide appropriate anchors for adjacent construction.

PART 3 - EXECUTION

3.01 INSTALLATION

A. **Coordination:** Coordinate and ensure that access panels provided under this contract are built into the structure at the proper location and elevation and at the proper time. Furnish access panels to appropriate Contractors for installation into their work.

B. **Access Doors to Be Furnished:** Contractor shall furnish access doors at locations to service the following: Control and shut-off valves, manual and automatic dampers, and fire dampers. Furnish access doors to access ductwork access doors and where shown on Drawings.

1. Contractor shall include the cost of 5 extra panels including installation cost in his Bid, minimum size of 24 by 24, for location during construction.

END OF SECTION

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PENETRATION SEALANTS FOR HVAC SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment, and accessories required to furnish and install through-penetration firestop systems at wall and floor openings.

B. **Related Sections:**

1.	Section 23 00 00:	Heating, Ventilating, and Air-Conditioning (HVAC) - General Requirements
2.	Section 23 07 00:	HVAC Insulation
3.	Section 23 09 23:	Direct-Digital Control System for HVAC
4.	Section 23 21 13.23:	Aboveground Hydronic Piping
5.	Section 23 23 00:	Refrigerant Piping
6.	Section 23 31 13:	Metal Ducts

1.02 REFERENCES

A. **General:** The following references refer to the latest version of the standards listed.

B. **ASTM International:**

1. ASTM E84, Surface Burning Characteristics of Building Materials
2. ASTM E814, Fire Tests of Through-Penetration Firestops

C. **Underwriters' Laboratories (UL):**

1. UL 1479, Fire Tests of Through-Penetrations Firestops
2. UL Building Materials Directory, Through-Penetration Firestop Systems (XHEZ), and Fill, Void or Cavity Materials (XHHW)

1.03 SUBMITTALS

A. **Instructions:** Submit manufacturer's instructions for applying sealant.

B. **Certification:**

1. Submit manufacturer's certifications that materials meet or exceed specified requirements.

2. Submit documentation of manufacturer's acceptance of applicator.

3. Provide certification stating that sealant has been completed in full accordance with requirements to provide necessary fire-resistance ratings.

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4. Provide (3) copies of certified test reports of:

   a. Fire test reports of sealant application to substrate materials shall be similar to Project conditions.

   b. Reports from reputable independent testing agencies of product proposed for use, indicating conformance with ASTM E814.

1.04 QUALITY ASSURANCE

A. **Qualifications:** Applicator shall be acceptable to sealant manufacturer.

B. **Regulatory Requirements:**

1. State Building Code Division

2. Local Codes and Ordinances

3. Local Authority having jurisdiction

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Bio-Fireshield, Inc., Concord, MA
2. Carborundum Company, Niagara Falls, NY
3. Dow Corning Corporation, Midland, MI
4. General Electric Company, Silicone Products Division, Waterford, NY
5. Hilti-Ciba-Geigy, Tulsa, OK
6. Metalines, Ind., Oklahoma City, OK
7. 3M Company, St. Paul, MN
8. Nelson Electric, a Unit of General Signal Corporation, Tulsa, OK
9. Tremco, Inc., Beachwood, OH
10. Rectorseal Corp., Houston, TX

2.02 MATERIALS

A. **Description:** Penetration sealant shall be a 1-component ceramic fiber-based putty fill, void or cavity material or 3M fire barrier caulk, putty strip, and sheet forms.

B. **Applications:** Flame Spread/Smoke Contribution shall be 0/0 in accordance with ASTM E84. UL rated material classified for use in Through-Penetration Firestop Systems shall be used for, but not limited to, the following:

1. Metal Pipe

2. Pneumatic Tubing:

   a. Carborundum material is not acceptable in this application.

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3. Glass Pipe / Plastic PVC / CPVC / Polypropylene:

   a. Carborundum material is not acceptable in this application.

4. Ductwork:

   a. Vertical and horizontal ductwork passing through floors and fire rated walls shall have space between duct and sleeve filled with an approved, fire rated caulk.

PART 3 - EXECUTION

3.01 EXAMINATION

A. **Verification of Conditions:**

1. Confirm compatibility of surfaces to receive sealant materials.

2. Verify that openings are sound, clean, dry, and ready to receive application of sealants.

3. Verify that penetration elements are securely fixed and properly located, with a minimum of space between penetrations and surfaces of openings.

4. Beginning of installation means acceptance of existing conditions.

3.02 PREPARATION

A. **Damage:** Protect adjacent surfaces and equipment from damage.

B. **Cleaning:** Clean contact surfaces of dirt, dust, grease, oil, loose material or other matter which may affect bond of sealant.

1. Remove incompatible materials which affect bond by scraping, brushing, scrubbing or sandblasting.

3.03 MOCK-UP

A. **General Requirements:** Apply (1) seal on representative substrates on-site for each fire rating required at each type of wall and floor construction. Confirm requirements of fire ratings.

1. Application shall be in accordance with Project requirements as to thickness and density to achieve fire rating.

B. **Acceptance:** Product and application shall be approved by governing authorities prior to continuing with the Work.

1. Approved mock-up may remain as part of the completed Work.

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3.04 APPLICATION

A. **Instructions:** Apply sealant in strict accordance with manufacturer's instructions.

B. **Rating:** Apply sealant in sufficient thickness to achieve required rating.

C. **Packing:** Pack material solidly around penetrations, fill openings to a depth as required by manufacturer's UL listing. Minimum shall be in accordance with fire ratings, for 1, 2, and 4 hours as required.

3.05 FIELD QUALITY CONTROL

A. **Inspection:** Perform inspection to verify that Work is in accordance with requirements.

1. Correct unacceptable work and provide further inspection to verify that Work meets requirements.

3.06 CLEANING

A. **Material:** Remove excess material, droppings, and debris.

B. **Sealant:** Remove sealant from materials and surfaces not specifically required to be sealed.

3.07 PROTECTION

A. **General Requirements:** Protect applied sealant from damage.

END OF SECTION

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SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:**

1. Testing, adjustment, and balancing of air systems.

2. Testing, adjustment, and balancing of hydronic and refrigerating systems.

3. Measurement of final operating condition of HVAC systems.

B. **Related Sections:**

1.	Section 23 00 00:	Heating, Ventilating, and Air-Conditioning (HVAC) - General Requirements
2.	Section 23 08 00:	Commissioning of HVAC
3.	Section 23 34 00:	HVAC Fans
4.	Section 23 36 00:	Air Terminal Units
5.	Section 23 37 00:	Air Outlets and Inlets
6.	Section 23 75 13:	Custom Outdoor DOAS Air-Handling Units
7.	Section 23 83 33:	Radiant Heat Equipment

1.02 REFERENCES

A. **American Association of Balancing Contractors (AABC):**

1. AABC National Standards for Total System Balance.

B. **Air Diffusion Council (ADC):**

1. ADC Test Code for Registers, Grilles and Diffusers.

C. **American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):**

1. ASHRAE 111, Practices for Measurement, Testing, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.

D. **National Environmental Balancing Bureau (NEBB):**

1. NEBB Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

E. **Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):**

1. SMACNA HVAC Systems Testing, Adjusting, and Balancing.

F. **Testing Adjusting Balancing Bureau (TABB):**

1. TABB National Standards for Total System Balance

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1.03 SUBMITTALS

A. Submit Under provisions of Section 01 33 00.

B. Submit name of adjusting and balancing agency for approval within 30 days after award of contract.

C. **Field Reports:** Submit under provisions of Section 01 33 00.

D. **Field Reports:** Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance prior to submitting final report.

E. Prior to commencing work, submit report forms or outlines indicating adjusting, balancing, and equipment data required.

F. Submit draft copies of report for review prior to final acceptance of Project. Provide final six (6) copies for distribution as follows: (1) Architect/Engineer, (2) for inclusion in Operating and Maintenance manuals, (1) for Contractor, (1) for Building Official and (1) for Commissioning Agent.

G. Provide reports in hard cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

H. Include detailed procedures, agenda, sample report forms and copy of AABC National Project Performance Guaranty prior to commencing system balance.

I. **Test Reports:** Indicate data on AABC National Standards for Total System Balance form or NEBB forms or TABB forms.

1.04 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 01 77 00.

B. Record actual locations of flow measuring stations balancing valves and rough settings.

1.05 QUALITY ASSURANCE

A. Perform total system balance in accordance with AABC National Standards for Field Measurement and Instrumentation, Total System Balance or NEBB procedural Standards for Testing, Balancing and Adjusting of Environmental Systems or TABB Testing Adjusting Balancing Bureau Standards.

1.06 QUALIFICATIONS

A. **Agency:** Company specializing in the testing, adjusting, and balancing of systems specified in this Section with technicians having a Minimum of three years documented experience certified by AABC, NEBB or TABB.

B. Perform work under supervision of AABC Certified Test and Balance Engineer or NEBB Certified Testing, Balancing and Adjusting Supervisor or TABB Certified Testing, Balancing and Adjusting Supervisor.

1.07 PRE-BALANCING CONFERENCE

A. Convene two weeks prior to commencing work of this section.

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1.08 SEQUENCING

A. Sequence work under the provisions of Section 01 11 00.

B. Sequence work to commence after completion of systems and schedule completion of work 30 days after Substantial Completion of Project. If scheduling requires the Contractor to work in building after or before regular scheduled school hours, the Contractor shall make arrangements with the school and if overtime is required, it will be provided at no additional cost to the Project.

1. Attend Project Contractors meetings beginning no later than 2 months prior to Substantial Completion. Coordinate balancing requirements with related Contractors prior to commencing balancing.

2. For "phased projects" (multiple projects performed over several stages), submit interim balancing reports for each phase to the Engineer for review and comment. Final report shall be compiled from all data included in interim reports.

3. Provide preliminary "Rough Balancing" for outside air systems and submit a draft report prior to Substantial Completion to allow for temporary occupancy permit approval by the municipality. Rough balance report shall include outdoor air CFMs delivered by units serving occupied areas.

1.09 SCHEDULING

A. Schedule Work Under Provisions of Section 01 33 00.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

3.01 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.

1. Contract Documents are defined in the General and Supplementary Conditions of the Contract.

2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers are properly installed by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 1 Section "Project Record Documents".

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.

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E. Examine equipment performance data including fan and pump curves. 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. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems - Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment startup test reports.

H. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

I. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

K. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

L. Examine strainers for clean screens and proper perforations.

M. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

N. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

O. Examine system pumps to ensure absence of entrained air in the suction piping.

P. Examine equipment for installation and for properly operating safety interlocks and controls.

Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.02 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.

2. Hydronic systems are filled, clean, and free of air.

3. Automatic temperature-control systems are operational.

4. Equipment and duct access doors are securely closed.

5. Balance, smoke, and fire dampers are open.

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6. Isolating and balancing valves are open and control valves are operational.

7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.

8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.03 INSTALLATION TOLERANCES

A. **Air Handling Systems:** Adjust to within plus or minus 10 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

B. **Air Outlets and Inlets:** Adjust total to within plus 10 percent and minus 10 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

1. Pressure Relationships: Where supply is balanced within listed tolerances plus or negative, the corresponding returns and or exhausts shall also be balanced to a similar plus or minus percentage to maintain pressure relationships in the spaces.

(Design supply = 200, Balance = 220, Return design 190, Balance = 209)

C. **Hydronic Systems:** Adjust to within plus or minus 10 percent of design.

3.04 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing of Heating, Ventilating, and Air Conditioning Systems", SMACNA-HVAC Systems Testing, Adjusting & Balancing, or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.05 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans, inlets and outlets. Obtain manufacturer's inlet/outlet factors and recommended testing procedures. Cross check the summation of required inlet/outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems "as-built" 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.

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E. Check airflow patterns from the outside-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 (no standing water).

K. Check for proper sealing of air-handling unit components.

L. Check for proper sealing of air duct system.

M. Check for correct installation of air flow measuring stations to verify that they measure air flows consistently throughout the full control sequence.

3.06 GENERAL PROCEDURES FOR MULTIPLE FAN AIR SYSTEMS

A. In systems where fans are acting in series (supply and direct ducted return fans) check air flows in each mode of operation (full return, full economizer and minimum air flow) to determine balance point of each fan. Adjust balance dampers between fans to avoid pressurizing mixed air chambers from the return fan.

B. Where supply fans and relief fans are in series, measure and adjust fan flows and pressure to provide the same negative static pressure by each fan.

C. Where balance dampers are not present, assist the EMCS in positioning the control dampers to provide correct air flows in each mode.

D. Where supply fans (direct drive type) are in parallel (fan wall configuration), measure and adjust fan speed to meet required air flows at each fan.

3.07 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:

a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.

b. Measure static pressure directly at the fan outlet or through the flexible connection.

c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.

d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

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2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and air-treating equipment.

    a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters. Assist EMCS Contractor with set-point for filter status setpoints.

3. Measure static pressures entering and leaving other devices such as sound traps and heat recovery equipment, under final balanced conditions.

4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

5. Obtain approval from Architect/Engineer for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.

6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

7. Assist EMCS Contractor in calibrating air flow measuring stations. Record outside air flows at 50 percent, 75 percent and 100 percent outside air flows. Obtain an EMCS print screen at corresponding capacities.

8. Assist EMCS Contractor in setting minimum outdoor air set-points and record damper positions.

9. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage. (Needs a minimum temperature difference of 30 degrees to be effective.)

B. Adjust volume dampers for main duct, sub-main ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

    a. Where sufficient space in sub-main and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Re-measure each sub-main and branch duct after all have been adjusted. Continue to adjust sub-main and branch ducts to indicated airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

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D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.

2. Adjust patterns of adjustable outlets for proper distribution without drafts as indicated on Drawings.

3.08 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. **Compensating for Diversity**: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. **Pressure-Independent, Variable-Air-Volume Systems**: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outside-air dampers at minimum, and return-air and exhaust-air dampers at a position that simulates full-cooling load.

2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.

3. Measure total system airflow. Adjust to within indicated airflow.

4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.

5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.

   a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the return/relief fan and balance the return-air ducts and inlets as described for constant-volume air systems.

7. Assist EMCS Contractor in calibrating air flow measuring stations. Record outside air flows at 50 percent, 75 percent and 100 percent outside air flows. Obtain an EMCS print screen at corresponding capacities.

8. Assist EMCS Contractor in setting minimum outdoor air setpoints and record damper positions.

9. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

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10. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.

11. Record the final fan performance data.

3.09 PROCEDURES FOR DEDICATED OUTDOOR AIR SYSTEMS (DOAS) WITH DISPLACEMENT AND CHILLED BEAMS

A. **Compensating for Diversity**: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. **Pressure-Independent, Variable-Air-Volume Systems**: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outside-air dampers at 100% open and return-air and exhaust-air dampers at a position that simulates full-cooling load.

2. Start at most remote chilled beam/displacement unit. Document terminal model number and nozzle types. Measure static pressure at each terminal unit supplied by a common VAV box. Verify with manufacturers capacity chart that correct airflow is being met. Verify that VAV box damper is in full open position (not over-rotated). Repeat with remaining terminal units on the DOAS unit.

3. Measure total system airflow. Adjust to within indicated airflow.

4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.

5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the return/relief fan and balance the return-air ducts and inlets as described for constant-volume air systems.

7. Assist EMCS Contractor in calibrating air flow measuring stations. Record outside air flows at 50 percent, 75 percent and 100 percent outside air flows. Obtain an EMCS print screen at corresponding capacities.

8. Assist EMCS Contractor in setting minimum outdoor air setpoints and record damper positions.

9. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

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10. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.

11. Record the final fan performance data.

3.10 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above.

1. Open all manual valves for maximum flow.

2. Check expansion tank liquid level.

3. Check makeup-water-station pressure gage for adequate pressure for highest vent.

4. Check flow-control valves for specified sequence of operation and set at indicated flow.

5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.

6. Set system controls so automatic control valves are wide open to heat exchangers.

7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.

8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

D. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

4. Report flow rates that are not within plus or minus 5 percent of design.

E. Set calibrated balancing valves, if installed, at calculated presettings.

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F. Measure flow at all stations and adjust, where necessary, to obtain first balance.

G. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

H. **Adjust balancing stations to within specified tolerances of indicated flow rate as follows:**

1. Determine the balancing station with the highest percentage over indicated flow.

2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.

3. Record settings and mark balancing devices.

I. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems pressures and temperatures including outdoor-air-temperature.

J. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.11 ADDITIONAL PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two-way and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

B. Assist the EMCS Contractor in establishing the correct pressure control set-point for the variable speed pumping system. Record set-point.

3.12 PROCEDURES FOR MOTORS

A. **Motors, 1/2 HP and Larger**: Test at final balanced conditions and record data.

B. **Motors Driven by Variable-Frequency Controllers**: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.13 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering-air and leaving-air temperatures.

C. Record compressor data.

3.14 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB reporting process there is the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet-bulb and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in one room on each air handling system, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

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3.15 REQUIRED MINIMUM DATA ON REPORT FORMS

A. **General Requirement:** Provide a print screen from the "Energy Management and Control System" for each test condition.

B. **Title Page:**

1. Name of Testing, Adjusting, and Balancing Agency
2. Address of Testing, Adjusting, and Balancing Agency
3. Telephone Number of Testing, Adjusting and Balancing Agency
4. Project Name
5. Project Location
6. Project Architect
7. Project Engineer
8. Project Contractor
9. Project Altitude
10. Report Date

C. **Summary Comments:**

1. Design versus final performance
2. Notable characteristics of system
3. Description of systems operation sequence
4. Summary of outdoor and exhaust flows to indicate amount of building pressurization
5. Nomenclature used throughout report
6. Test conditions

D. **Instrument List:**

1. Instrument
2. Manufacturer
3. Model number
4. Serial number
5. Range
6. Calibration date

E. **Electric Motors:**

1. Manufacturer, model, and serial number
2. Motor horsepower rating
3. Motor rpm
4. Efficiency rating
5. Nameplate and measured voltage, each phase
6. Nameplate and measured amperage, each phase
7. Starter thermal-protection-element rating

F. **V-Belt Drive:**

1. Identification/location
2. Required driven RPM
3. Driven sheave, diameter and RPM
4. Belt, size and quantity
5. Motor sheave diameter and RPM
6. Center to center distance, maximum, minimum, and actual

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G. **Direct Drive:**

1. Identification/location
2. Required driven speed
3. Required Amp draw on motor
4. Maximum Amp draw on motor

H. **Variable Frequency Drive:**

1. Identification/location
2. Required driven speed in Hertz
3. Amp draw on motor
4. Nameplate Amps on motor

I. **Air Cooled Condenser:**

1. Identification/number
2. Location
3. Manufacturer
4. Model number
5. Serial number
6. Entering DB air temperature, design and actual
7. Leaving DB air temperature, design and actual
8. Number of compressors

J. **Refrigerant Coils:**

1. Entering air DB temperature, design and actual
2. Entering air WB temperature, design and actual
3. Leaving air DB temperature, design and actual
4. Leaving air WB temperature, design and actual
5. Air flow, design and actual
6. Air pressure drop, design and actual
7. Refrigerant suction pressure and temperature

K. **Heating Coil Data:**

1. Identification/number
2. Location
3. Service
4. Manufacturer
5. Air flow, design and actual
6. Water flow, design and actual
7. Water pressure drop, design and actual
8. Entering water temperature, design and actual
9. Leaving water temperature, design and actual
10. Entering air temperature, design and actual
11. Leaving air temperature, design and actual
12. Air pressure drop, design and actual

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L. **Air Moving Equipment:**

1. Location
2. Manufacturer
3. Model number
4. Serial number
5. Arrangement/Class/Discharge
6. Supply air flow, specified and actual
7. Return air flow, specified and actual
8. Minimum outside air flow, specified and actual
9. Total static pressure (total external), specified and actual
10. Inlet pressure
11. Discharge pressure
12. Sheave(s) Make/Size/Bore
13. Number of Belts/Make Size
14. Fan RPM
15. System component air pressure drops (system profile)

M. **Packaged Heat Recovery Unit:**

1. Location
2. Manufacturer (supply fan and exhaust fan)
3. Model Number (supply fan and exhaust fan)
4. Serial Number (supply fan and exhaust fan)
5. Arrangement/Class/Disclosure (supply fan and exhaust fan)
6. Air Flow, specified and actual (supply fan and exhaust fan)
7. Exhaust air flow (supply fan and exhaust fan)
8. Supply air flow (supply fan and exhaust fan)
9. Total static pressure (total external) (supply fan and exhaust fan)
10. Inlet pressure (supply fan and exhaust fan)
11. Discharge pressure (supply fan and exhaust fan)
12. Sheave Make/Size Bore (supply fan and exhaust fan)
13. Number of Belts/Make/Size (supply fan and exhaust fan)
14. Fan RPM (supply fan and exhaust fan)

N. **Return Air/Outside Air Data:**

1. Identification/location
2. Design air flow
3. Actual air flow
4. Design return air flow
5. Actual return air flow
6. Design outside air flow
7. Actual outside air flow
8. Design air temperature
9. Actual air temperature
10. Design outside/return air ratio
11. Actual outside/return air ratio

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O. **Exhaust and Return Fan Data:**

1. Location
2. Manufacturer
3. Model number
4. Serial number
5. Air flow, specified and actual
6. Total static pressure (total external), specified and actual
7. Inlet pressure
8. Discharge pressure
9. Sheave make/size/bore
10. Number of belts/make/size
11. Fan RPM

P. **Duct Traverse:**

1. System zone/branch
2. Duct size
3. Area
4. Design velocity
5. Design air flow
6. Test velocity
7. Test air flow
8. Duct static pressure
9. Air temperature
10. Air correction factor

Q. **Duct Leak Test:**

1. Description of ductwork under test
2. Duct design operating pressure
3. Duct design test static pressure
4. Duct capacity, air flow
5. Maximum allowable leakage duct capacity times leak factor
6. Test apparatus:
    a. Blower
    b. Orifice, tube size
    c. Orifice size
    d. Calibrated
7. Test static pressure
8. Test orifice differential pressure
9. Leakage

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R. **Flow Measuring Station (Air and Water):**

1. Identification number
2. Location
3. Size
4. Manufacturer
5. Model number
6. Serial number
7. Design flow rate
8. Design pressure drop
9. Actual/final pressure drop
10. Actual/final flow rate
11. Station calibrated setting

S. **Terminal Unit Data:**

1. Manufacturer
2. Type, constant, variable, single, dual duct
3. Identification/number
4. Location
5. Model number
6. Size
7. Minimum static pressure
8. Minimum design air flow
9. Maximum design air flow
10. Maximum actual air flow
11. Inlet static pressure

T. **Chilled Beams/Displacement Unit Data:**

1. Manufacturer
2. Identification/number
3. Location
4. Model number
5. Size
6. Design air flow
7. Design nozzle pressure drop
8. Final nozzle pressure drop
9. Final air flow

U. **Air Distribution Test Sheet:**

1. Air terminal number
2. Room number/location
3. Terminal type
4. Terminal size
5. Area factor
6. Design velocity
7. Design air flow
8. Test (final) velocity
9. Test (final) air flow
10. Percent of design air flow

END OF SECTION

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SECTION 23 07 00

HVAC INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, materials, equipment and accessories for the installation of thermal and acoustical insulation for heating, and air conditioning piping and ductwork in strict accordance with insulation Section of the Specification and applicable Drawings.

1. Insulate piping and fittings, including heating and cooling control valve bodies and union fittings up to unit coil connection.

2. Insulate ventilation, heating, air conditioning and exhaust ductwork and fittings, as specified or indicated on Drawings.

B. **Related Sections:**

1.	Section 23 00 00:	Heating, Ventilating, and Air-Conditioning (HVAC) - General Requirements
2.	Section 23 05 23:	General-Duty Valves for HVAC Piping
3.	Section 23 05 30:	Hydronic Specialties
4.	Section 23 21 13.23:	Aboveground Hydronic Piping
5.	Section 23 23 00:	Refrigerant Piping
6.	Section 23 31 13:	Metal Ducts

1.02 REFERENCES

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

1. ASTM E84-82: Test Method for Surface Burning Characteristics of Building Materials.

B. **National Fire Protection Agency (NFPA):**

1. NFPA 255: Tests for Surface Burning Characteristics of Building Materials.

C. **Underwriters' Laboratories (UL):**

1. UL 723

1.03 SUBMITTALS

A. **Shop Drawings:** Contractor shall submit a list of insulation to be used prior to beginning any application work.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

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1.05 QUALITY ASSURANCE

A. **Regulatory Requirements:**

1. State Building Code

2. Local Codes and Ordinances

3. Local Authority having jurisdiction

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Johns Manville
2. Armaflex/Armacell
3. Imcoa
4. Knauf
5. Owens-Corning
6. CertainTeed

B. **Insulation Materials:** Insulation materials manufacturing facilities must be certified and registered with an approved Registrar for conformance with ISO 9000 Quality Standard.

C. **Fire and Smoke Hazard Ratings:**

1. Insulation shall have composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to the insulation) fire and smoke hazard ratings as tested by procedure ASTM E84, NFPA 255 and UL 723 not exceeding:

   a. Flame Spread 25

   b. Smoke Developed 50

2. Accessories, including adhesives, mastics, cement tapes, glass fabric, and fire resistant cloth for fittings, shall have the same component ratings as listed above.

3. Products or their shipping cartons or packages shall bear a label indicating that flame and smoke ratings do not exceed above requirements. Stencil duct liners with "MEETS 90A REQUIREMENTS".

4. All insulation used for mechanical systems shall have the name of the manufacturer, the thermal resistance R-value at the specified installation thickness, and the flame spread and smoke-developed ratings of the composite materials.

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2.02 MATERIALS

A. **Jackets and Facing Descriptions**: Poly-encapsulated paper jacket bonded to aluminum foil, reinforced with fiberglass yarn. Poly-encapsulated paper jacket to be permanently treated for fire and smoke safety, and to prevent corrosion of foil. Beach puncture 50 ox. in./in./year, tensile strength 35 pounds per inch width, Mullen Burst 70 psi, perm rating 0.02 perm. AP-T shall be a factory applied self-seal system and may be used at the Contractor's option.

1. FSK reinforced foil and paper (Foil Scrim Kraft). Aluminum foil, minimum 0.75 mil thick, reinforced with fiber glass yarn mesh and laminated to 40 pound chemically treated fire resistant Poly-encapsulated paper jacket, Underwriters' Laboratories rated.

2. Dura Mesh glass fabric shall be white resin coated 10 by 10 mesh.

3. PVC pipe jacketing and fitting covers, high-impact, white, 20 mil, UV resistant PVC jacketing and preformed fitting covers applied with waterproof adhesive, all components meeting the 25/50 fire and smoke hazard ratings. Johns Manville Zeston 2000 with Perma-Weld adhesive.

B. **Inserts**: Install insulation inserts at outside hangers and supports for piping 1-1/2 inches and larger. Inserts between the pipe and pipe hangers shall be of equal thickness to the adjoining insulation and insulation saddles, and shall be provided with a vapor barrier. Insulation inserts shall be as manufactured by Pipe Shields Incorporated, Insul-Shield Uni-Grip or Johns ManvilleThermo 12/Gold. Shield shall be installed between hanger and insulation on all piping.

PIPE SIZE	"INSULATION" INSERTS NOT LESS THAN THE FOLLOWING LENGTHS	SHIELD LENGTH	MINIMUM GAUGE
Less Than 1-1/2 Inches	—	10 Inches	26
1-1/2 Inch to 2-1/2 Inches	10 inches Long	12 Inches	24
3 Inches to 6 Inches	12 inches Long	14 Inches	20
8 Inches to 10 Inches	16 inches Long	18 Inches	16
12 Inches and Over	22 inches Long	24 Inches	16

1. At hanger and support points for insulated piping, install an insert around the lower 1/3 circumference. Shields shall overlap inserts 1 inch on each side.

2. Insulation shields shall be installed between insulation and pipe hangers for all pipe sizes.

C. **Glass Fiber Insulation**: Johns Manville "Micro-Lok" AP-T, meeting ASTM C547 or approved equal, having average thermal conductivity not exceeding 0.23 Btu per inch per square foot per degrees F per hour at mean temperature of 75 degrees F.

D. **Elastomeric Foam Insulation**: Rubatex R-180-FS tubing insulation been compounded to meet the indicated flame spread and smoke density rating.

1. Insulation thicknesses of 3/8, 1/2, and 3/4 inch, tested independently, shall have a maximum fire/smoke rating of 25/50. Other thicknesses are rated at 25/100.

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E. **Calcium Silicate Insulation:** Johns Manville Thermo-12/Gold, asbestos free color coded hydrous calcium silicate, meeting ASTM C533 or approved equal.

1. Insulate fittings and valves 3 inches and smaller with Ryder's Thermokote V cement to same thickness as adjacent pipe insulation. Insulate over 3 inches with mitered segments of pipe insulation wired in place and finished with Thermokote V Cement. Fittings for temperatures 600 degrees F and over shall be made up in double layer construction.

2. Seal canvas on pipe insulation and fittings with mildew resistant adhesive, Benjamin Foster 81-42W.

F. **Flexible Cellular Polyolefin Foam (IMCOA) ASTM C534:**

1. Insulation: Imcoa, Imcolock with pre-slit longitudinal seam with each mating surface adhesive coated and protected with a mylar release liner.

a. No external vapor barrier jacket shall be required if the water vapor permeability is 0.01 perm inch or less. Insulation which is U.V. stabilized can be exposed to sunlight and weathering without any special paint coating. The insulation can be directly buried underground without any protective jacket if the manufacturer warrants its underground use.

2. Description: Imcolock shall comply with ASTM C-534, UL94HBF, UBC42-1 Class I, ASTM E-84 25/50, NFPA 255, UL723.

a.	K Factor: ASTM C177	.24 at 75 degrees F .26 at 90 degrees F
b.	Moisture Vapor Transmission: ASTM E96	(0.0) Zero perm inch
c.	Minimum Service Temperature:	-110 degrees F
d.	Maximum Service Temperature:	210 degrees F
e.	Maximum Flame Spread: ASTM E84	25
f.	Maximum Smoke Developed: ASTM E84	50
g.	Shall contain no potential corrosive constituents associated with stress corrosion failure of copper tubing.	

h. Connection Method	Piping System Temperature Range	
1) Fuse-Seal Hot Melt Method	-110 degrees	+210 degrees
2) Contact Adhesive (Mfg. Approval)	-110 degrees	+210 degrees
3) Lap seal end joint tape recommended by insulation manufacturer	32 degrees	+210 degrees

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PART 3 - EXECUTION

3.01 PIPING SPECIALTIES REQUIREMENTS

A. **General Requirements:** Insulation shall be applied on clean, dry surfaces. Contractor shall clean and prepare all surfaces to be insulated prior to application.

1. Insulation shall be continuous through wall and ceiling openings and sleeves.

a. Where insulated pipe passes through a fire rated wall, ceiling or floor, insulation shall stop at fire barrier face and start at opposite side. On chilled water piping, the insulation shall carry through the sleeve with no unsealed joints.

2. Insulation on cold surfaces where vapor barrier jackets are used shall be applied with a continuous, unbroken vapor seal. Hangers, supports and anchors that are secured directly to cold surfaces shall be adequately insulated and vapor-sealed by cementing pieces of vapor barrier over and around same.

B. **Fittings, Expansion Joints, Valve Bodies, Strainers, and Flanges:** Insulate elbows, tees, and valves with Johns Manville Zeston 2000 system of premolded PVC fittings and fiberglass inserts installed in accordance with manufacturer's instructions. Fittings may be insulated with 3/4 pound Microlite blanket compressed to 1/2 the thickness of adjoining pipe covering and secured with 3-ply jute twine or mitered pipe insulation segments secured with 3-ply jute twine and finished with Ryder's Thermokote No. 1 cement. After cement is dry, finish fittings with two coats Benjamin Foster 30-36 reinforced with Dura-Mesh or 6 ounce canvas overlapping adjacent jacket.

3.02 INSULATING PIPING

A. **General Requirements:** Insulate piping with Johns Manville Micro-Lok HP Ultra jacketed fiberglass, IMCOA insulation or approved equal as indicated.

1. Seal jacket laps and end laps with Insul-Coustic 215 or approved equal mastic applied to two surfaces.

2. Piping run in walls shall be fully insulated.

3. Piping shall be insulated up to coil headers of all equipment unless noted otherwise.

4. Heating and Tertiary Piping connections to Chilled Beams and Displacement Units may be insulated with 1 inch thick Rubatex pipe insulation.

B. **Air Conditioning Drain Lines Insulation:** Insulate drain lines not in mechanical equipment rooms with fiberglass or IMCOA insulation in accordance with the following schedule:

PIPE SIZE	THICKNESS
Through 1 Inch	1/2 Inch Thick
1-1/4 Inches Through 6 Inches	1 Inch Thick
8 Inches & above	1.5 Inch Thick

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C. **Glycol & Non-Glycol Hot Water Heating Supply and Return Piping Insulation:** Insulation pipe and fittings shall be complete up to coil headers of mechanical units unless noted otherwise. End of Strainers with plug shall not be covered. Pipe insulation shall be fiberglass in accordance with the following schedule:

FLUID TEMP 105 THROUGH 200 DEGREES	
PIPE SIZE	**THICKNESS**
Less than 1 Inch	1-1/2 Inch Thick
1 Inch Through 1-1/4 Inches	1-1/2 Inch Thick
1-1/2 Inches Through 6 Inches	2 Inch Thick
8 Inches and Over	2 Inch Thick

1. Hot water supply and return piping in radiator covers shall not be insulated unless noted otherwise on Drawings.

3.03 INSULATING STEAM AND CONDENSATE PIPING

A. **General Requirements:** Insulate piping under 500 degrees F with Johns Manville Micro-Lok AP-T jacketed fiberglass pipe insulation, or approved equal.

1. Insulation of steam and condensate pipe and fittings shall be complete up to unit casing of air handling units, cabinet unit heaters, unit heaters, convectors, unit ventilators, and other mechanical units. End of strainers with plug shall not be covered.

B. **Steam and Condensate Piping Insulation Schedule - Low Pressure:**

PIPE SIZE	STEAM PIPE INSULATION	CONDENSATE PIPE INSULATION
1/2 Inch Through 3 Inch	2-1/2 Inches	2 Inch
4 Inches and Over	3 Inches	2 Inches

3.04 INSULATING DIRECT EXPANSION REFRIGERANT PIPING

A. **Insulation:** Insulate refrigerant suction and hot gas line piping with flexible cellular polyolefin foam pipe insulation.

B. **Exterior Insulation:** Insulate refrigerant suction, liquid line and hot gas piping, exposed to weather, or below grade, with flexible cellular polyolefin foam insulation. Provide a PVC jacket on the piping that is exposed to weather. In lieu of flexible cellular polyolefin foam insulation, Contractor may use HT/Armaflex insulation.

C. **Fittings:** Insulate sweat type fittings with flexible cellular polyolefin foam of same size as that used on adjacent tubing.

1. Bond slit and butt joints with flexible cellular polyolefin foam adhesive (Fuse-Seal).

2. Insulate screwed type fittings with sleeves of aerotube having an inside diameter large enough to overlap the insulation of adjacent tubing or pipe.

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3. Sleeves shall be made by cementing 2 miter-cut pieces of larger size flexible cellular polyolefin foam together.

D. **Application:** Bond joints and butt ends with adhesive by applying to both surfaces. Press both surfaces together after adhesive is non-tacky to touch.

E. **Direct Expansion Refrigerant Piping Insulation Schedule:**

PIPE SIZE	THICKNESS
Through 1-1/2 Inch	1 Inch Thick
2 Inch and Over	1-1/2 Inch Thick

3.05 INSULATING FOR PIPING OUTSIDE BUILDING EXPOSED TO WEATHER

A. **Insulated Pipe Exposed to Weather:** Insulate service water, including domestic hot, cold, and circulating water; chilled water; hot water heating; and steam and condensate piping, when exposed to the elements, with Johns Manville metal jacketed fiberglass pipe insulation, or approved equal. Jacket insulation with a minimum thickness of 0.016 inch aluminum, No. 5005. Provide a moisture barrier between insulation and jacket.

1. Secure insulation and jacket in place by continuous friction type joint providing positive weather-proof seal.

2. Snap, strap and clip, 0.016 inch aluminum, 2 inches wide with weather-proof sealant, and place at each circumferential joint.

3. Insulate fittings with mitered sections of Micro-Lock. Seal joints with a sealing compound and preformed aluminum bands and formed fitting covers.

4. Pipe insulation may be calcium-silicate in lieu of fiberglass.

3.06 INSULATING COIL HEADERS

A. **General Requirements:** Insulate exposed heating and cooling coil headers at air handling units with 1 inch thick, 3 pound density fiberglass board boxed over return bends with all-purpose covering overlapping sheet metal 2 inches and secured with adhesive glass cloth tape.

B. VAV box coil headers shall be insulated with external duct insulation.

3.07 INSULATING HOT WATER; AIR SEPARATORS, SIDE STREAM FILTERS, AND CONVERTORS/HEAT EXCHANGERS

A. **Thermal Insulation Schedule:** Insulate the above hot equipment with Micro-Flex large-diameter pipe and tank fiberglass wrap insulation with FSK facing in accordance with the following schedule:

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TEMPERATURE	THICKNESS
150 Degrees F	2 Inches
200 Degrees F	3 Inches
250 Degrees F	3-1/2 Inches

1. Insulation shall be cut, scored or mitered to fit contour of equipment with edges tightly butted and secured with staples and seal with matching pressure-sensitive tape. Provide banding where application requires additional securement.

3.08 INSTALLATION APPLICATION - EXTERNAL DUCT INSULATION

A. **Fiber Glass Blanket Insulation:**

1. Apply insulation with edges tightly butted and secured over mastic adhesive applied in 6 inch wide strips around full perimeter of duct on 18 inch centers. Ductwork larger than 16 inches wide shall have welded pins and clips applied to bottom of duct on 15 inch centers holding insulation to duct.

2. Insulation joints shall have both edges buttered with mastic, lapped not less that 2 inch width, and firmly adhered together.

3. Staples may be used to hold adhesive joints while drying. Vapor barrier shall not have open penetrations.

4. Ductwork 16 inches and smaller may be less welded pins and clips, but shall have 2 inch wide adhesive tape applied on 4 foot centers completely around duct with 4 inch overlap at ends. Vertical ductwork and sides of duct 36 inches and greater shall have welded pins and clips on bottom third of duct on 18 inch centers.

5. Round ducts greater than 16 inch diameter shall have welded pins and clips on bottom third of duct on 18 inch centers, with 4 inch wide glass fiber tape glued over joints and ends stapled. Round ducts 16 inches and smaller may be less pins and clips, but shall have 4 inch overlap at ends.

B. **Fiber Glass Board Insulation:**

1. Apply insulation with edges buttered with mastic and tightly butt and impale over welded pins and secure with clips. Space pins to hold insulation securely in place, but not over 18 inches on center. Seal joints with 4 inch wide glass cloth vapor barrier tape, permanently glued in place, ends stapled.

2. Insulate exposed round and oval ducts similar as concealed ducts, unless otherwise indicated.

3.09 EXTERNAL DUCT INSULATION SCHEDULE

A. **Schedule:** Provide insulation on the following ductwork systems as indicated:

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Type of Duct System	Type of Insulation	Thickness	Density
HVAC Ductwork: Supply ductwork shall be externally insulated from air handling unit to air outlet.	Fiber glass blanket insulation in concealed areas.	1-1/2"	1 pound
	Fiber glass board insulation in exposed areas.	1-1/2"	3 pound
HVAC Ductwork: Return ductwork in non-return air plenum shall be externally insulated from air handling unit to air outlet.	Fiber glass blanket insulation in concealed areas.	1-1/2"	1 pound
	Fiber glass board insulation in exposed areas.	1-1/2"	3 pound
Exhaust Ductwork: Vertical ductwork from roof penetrations to drip pans, drip pans, and exhaust/relief louver plenums shall be externally insulated. If horizontal ductwork is not internally lined, provide external insulation for 15 feet from drip pan. (See separate article in this Section for Kitchen exhaust ductwork insulation).	Fiber glass blanket insulation in concealed areas.	1-1/2"	1 pound
	Fiber glass board insulation in exposed areas.	1-1/2"	3 pound
Relief Ductwork: Shall be externally insulated for 15 feet from roof opening or louver.	Fiber glass blanket insulation in concealed areas.	1-1/2"	1 pound
	Fiber glass board insulation in exposed areas.	1-1/2"	3 pound
Energy Recovery Unit Supply Ductwork: Ductwork shall be externally insulated from energy recovery unit supply outlet to air handling unit mixing box. (Note: All ductwork exposed to weather shall be double-wall ductwork. Refer to Section 23 31 13.)	Fiber glass board insulation.	2"	3 pound
Outside Air Ductwork: Outside air Ductwork shall be externally insulated from intake hood/louver to the air handling unit mixing box.	Fiber glass board insulation.	2"	3 pound
Mixed Air Ductwork: Mixed air ductwork shall be externally insulated.	Fiber glass board insulation.	1-1/2"	3 pound

B. **General Requirements**:

1. External duct insulation shall be omitted where double wall duct construction is used and where internal lining is used. See Section 23 31 13 of the Specifications.

END OF SECTION

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SECTION 23 08 00

COMMISSIONING OF HVAC

PART 1 - GENERAL

1.01 DEFINITION

A. **General:** The purpose of this Section is to specify the Division 23 responsibilities and participation in the commissioning process. The Commissioning Authority will be a separate Contract by the Owner. The Contractor, and their subcontractors and suppliers shall provide the necessary manpower to provide the required assistance for the Commissioning process to complete the Work. The Contractor shall include in their bid the cost of their participation along with their subcontractors and suppliers in the Commissioning work of this Contract.

B. **Reference:** Work under this Contract shall conform to requirements of Division 1, General Requirements, Conditions of the Contract, and Supplementary Conditions. This Specification covers commissioning of mechanical systems which are part of this Project.

C. **Coordination:** Commissioning work shall be a team effort to ensure that all mechanical equipment and systems have been completely and properly installed, function together correctly to meet the design intent, and documents system performance parameters for tuning of control sequences and operational procedures. Commissioning shall coordinate system documentation, equipment start-up, control system calibration, testing and balancing, and verification and performance testing.

D. **Commissioning Team:** The commissioning team shall be made up of representatives from the Owner, design professionals, major equipment suppliers and construction trades. The trades represented on the commissioning team shall include, but not be limited to, sheet metal, piping and fitting, controls, test and balance, and electrical. The lead person for each trade who will actually perform or supervise the work is to be designated as the representative to the commissioning team. Responsibility for various steps of the commissioning process shall be divided among the members of the commissioning team, as described in this Section.

E. **Commissioning Authority:** The Commissioning Authority shall have responsibility for coordinating and directing each step of the commissioning process.

F. **Responsibility:** Mechanical system installation, start-up, testing, balancing, preparation of O&M manuals, and operator training are the responsibility of the Division 23 Contractors, with coordination, observation, verification and commissioning the responsibility of Commissioning Authority. The commissioning process (work done by the Commissioning Authority) does not relieve Division 23 from the obligations to complete all portions of work in a satisfactory and fully operational manner.

1.02 SCOPE OF WORK

A. **General:** Commissioning work of Division 23 shall include, but not be limited to:

1. Testing and start-up of the equipment.

2. Testing, adjusting and balancing of hydronic and air systems.

3. Cooperation with the Commissioning Authority.

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4. Providing qualified personnel for participation in commissioning tests, including seasonal testing required after the initial testing.

5. Providing equipment, materials, and labor as necessary to correct construction and/or equipment deficiencies found during the commissioning process.

6. Providing operation and maintenance manuals, and As-Built Drawings to the Commissioning Authority for verification.

7. Providing training and demonstrations for the systems specified in Division 23.

B. **Work Included:** The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems, and sub-systems. The following equipment and systems shall be evaluated:

1. Automatic temperature controls.
2. Air handling systems.
3. Hydronic distribution systems.
4. Electric heating systems.
5. Air distribution and exhaust systems.
6. Domestic hot water systems.
7. Variable frequency drives.
8. Fire protection/suppression systems.
9. EMCS control systems.
10. Other:
    a. Indoor Air Quality (IAQ).
    b. Computer Room AC (as applicable).
    c. Kitchen HVAC.

C. **Documentation:** Timely and accurate documentation is essential for the commissioning process to be effective. Documentation required as part of the commissioning process shall include but not be limited to:

1. Progress and status reports, including deficiencies noted.
2. Minutes from all meetings.
3. Pre-start, and start-up procedures.
4. Training agenda and materials.
5. As-built records.
6. Commissioning report.
7. Operation and maintenance (O&M) manuals.

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D. **Testing**: Detailed testing shall be performed on all installed equipment and systems to ensure that operation and performance conform to Contract Documents. All tests shall be witnessed by the Commissioning Authority. The following testing is required as part of the commissioning process:

1. Verification tests are comprised of a full range of checks and tests to determine that all components, equipment systems, and interfaces between systems operate in accordance with Contract Documents. This includes all operating modes, interlocks, control responses, and specific response to abnormal or emergency conditions.

2. Functional performance tests (FPT) shall determine if the HVAC system is providing the required cooling and heating services in accordance with the finalized design intent. These tests shall also determine the installed capacity of the cooling and heating plant, and the individual heat transfer components.

E. **Training**: Comprehensive training of O&M personnel shall be performed by the applicable Mechanical Contractor, and where appropriate, by other sub-contractors, and vendors prior to turnover of building to the Owner. The training shall include classroom instruction, along with hands-on instruction on the installed equipment and systems.

F. **Sequence:** Attached is a typical Commissioning Sequence for reference.

1.03 ROLES AND RESPONSIBILITIES

A. **Owner**:

1. Assign maintenance personnel and schedule them to participate in meetings, training sessions and inspections as follows:

   a. Construction Phase coordination meeting.
   b. Initial Owner training session at initial placement of major equipment.
   c. Maintenance orientation and inspection.
   d. Piping and ductwork test and flushing verification meetings.
   e. Procedures meeting for Testing, Adjusting and Balancing.
   f. Owners training session.
   g. Verification demonstrations.
   h. Final review at acceptance meeting.

2. Provide qualified personnel for video taping and editing of training sessions.

3. Video tape construction progress, hidden shafts, etc. (optional)

4. Provide any utilities required for the commissioning process.

5. Provide detailed program clearly stating the Owner's objectives, parameters, budgets, etc. for this facility.

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B. **Commissioning Authority:**

1. Develop the commissioning requirements and all related testing, verification and quality control sections.

2. Prepare the mechanical commissioning program required as part of the Commissioning Specification. Include list of all Contractors for commissioning events by name, firm and trade specialty.

3. Execute the mechanical commissioning program, through organization of all meetings, tests, demonstrations, training events and performance verifications described in the Contract Documents and approved HVAC commissioning program. Organizational responsibilities include preparation of agendas, attendance lists, arrangements for facilities and timely notification to participants for each commissioning event. The Commissioning Authority shall act as chairman at all commissioning events and assure execution of all agenda items. The Commissioning Authority shall act as chairperson at all commissioning events and assure execution of all agenda items. The Commissioning Authority shall prepare minutes of every commissioning event and send copies to all attendees and the Owner within 5 work days of the event.

4. Review the design documents for their affect on the commissioning process and the final performance of the HVAC system. This includes ensuring that appropriate commissioning guidelines have been followed, and that there are adequate devices included in the design to ensure the ability to properly test, adjust, and balance the systems, and to document the performance of each piece of equipment and each system. Any items required but not shown shall be brought to the attention of the Contractor prior to submittal of Shop Drawings.

5. Review all submittals (e.g. equipment, ductwork, piping, automatic controls, and TAB procedures) for their affect on the commissioning process and the final performance of the HVAC system.

6. Schedule the Construction Phase coordination meeting within 90 days of the award of the Contract, at some convenient location and at a time suitable to the Contractor and Design Professional. This meeting shall be for the purpose of reviewing the complete mechanical commissioning program and establishing tentative schedules for mechanical system orientation and inspections, O&M submittals, training sessions, system flushing and testing, job completion, test, adjust and balance (TAB) work, and verification and functional performance testing.

7. Schedule the initial Owner training session so that it will be held immediately before the mechanical system orientation and inspection. This session shall be attended by the Owner's O&M personnel, the applicable Mechanical Contractor(s), the Design Professional and the Commissioning Authority. The Design Professional shall conduct this session giving an overview of the system, the system design goals and the reasoning behind the selection of the equipment.

8. Conduct periodic inspections of work in progress to ensure that all systems and equipment are installed according to Specifications.

9. Conduct the Mechanical system orientation and inspection following the initial training session. The Mechanical system orientation and inspection shall be conducted by the applicable Mechanical Contractor. The emphasis of this Mechanical system orientation and inspection shall be an observation of the equipment location with respect to accessibility. Prepare minutes of this meeting, with separate summary of deficiency findings by the Owner and Commissioning Authority and distribute to attendees and the Owner.

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10. Receive and review the Operation and Maintenance (O&M) manuals as submitted by the Contractor, ensuring that they followed the specified outline and format. Insert systems description as provided by the Design Professional.

11. Adequate accessibility for maintenance and component replacement or repair is the General Contractor responsibility and shall be checked by the Commissioning Authority.

12. Witness equipment and system start-up and testing. Ensure the results are documented (including a summary of deficiencies), and incorporated in the O&M manuals.

13. Prior to initiating the TAB work, the Commissioning Authority shall meet with the Owner, applicable Mechanical Contractor, Design Professional and TAB Contractor. The TAB Contractor shall outline TAB procedures and get concurrence from the Design Professional and Commissioning Authority. Ensure that the TAB Contractor has all forms required for the job database and understands their importance and use.

14. Schedule the O&M training sessions. These training sessions are to be attended by the Owner, Commissioning Authority, Design Professional, General Contractor, Contractors and equipment suppliers as necessary. The format shall follow the outline in the O&M manuals. This mechanical system orientation and inspection should include hands on training.

15. Submit detailed verification test procedures and data sheets for review by the Design Professional.

16. Submit detailed FPT procedures for review and acceptance by the Design Professional.

17. Upon receipt of notification from the Design Professional that the mechanical systems have been completed and are operational, the Commissioning Authority shall proceed to verify the TAB report and operation of the control systems in accordance with the Commissioning Specification.

18. Conduct verification tests.

19. Submit verification test data for review to the Design Professional for review and acceptance.

20. Provide detailed checklist data sheets to document verification tests.

21. Provide and install calibrated test instrumentation to monitor and record data as necessary.

22. The Commissioning Authority shall certify that the mechanical systems are ready for Functional Performance Testing.

23. Conduct Functional Performance Tests. The test data shall be part of the commissioning report.

24. Submit Functional Performance Test report for review to the Design Professional.

25. Re-test if performance deficiencies are found, corrected, and additional testing is required.

26. Review Record Drawings for accuracy with respect to the installed systems. Request revisions to achieve accuracy.

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27. Ensure that the O&M manuals, and all other as-built records have been updated to include all modification made during the construction phase.

28. Repeat Functional Performance Tests to accommodate seasonal tests and/or correct any performance deficiencies. Revise and re-submit the commissioning report.

29. Prepare the final commissioning report.

30. Assemble the final Project documentation which shall include the commissioning report, and all as-built records. Submit this documentation to the Design Professional for review and acceptance.

C. **Architect:**

1. Provide support to the Design Professional who must provide a service as a part of the commissioning process. This shall include providing adequate space for equipment installation and maintenance.

2. Conduct periodic inspections of work in progress to ensure that all systems and equipment are installed according to Specifications.

3. Provide data (MSDS) on structure, building materials, interior finishes, and furnishings for their effect on indoor air quality.

D. **Mechanical Design Professional:**

1. Provide documentation of initial design concepts, and Design Intent based on the Owner's program.

2. Provide mechanical system design parameters and obtain approval of Owner.

3. Prepare Contract Documents incorporating the Commissioning Specification requirements and description of the mechanical system.

4. The Design Professional shall specify and verify adequate maintenance accessibility for each piece of equipment described in Shop Drawings and the actual installation. Periodic inspections are part of the Design Professional's construction administration duties.

5. The Design Professional retains responsibility for the system evaluation, adequacy of the system to meet design intent, capacity of the system, quality control check or any of the other elements of the system design.

6. Attend the Owner training sessions. Conduct the mechanical training session pertaining to the overview of the system design, the system design goals and the reasoning behind the selection of equipment.

7. Participate in O&M personnel orientation and inspection at the final construction stage.

8. Attend initial meeting with TAB representative as scheduled by Commissioning Authority.

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9. Review verification and functional performance testing procedures submitted by the Commissioning Authority.

10. Review TAB report and verification data sheets for system conformance to Contract Documents. Issue a report noting deficiencies requiring correction to the Commissioning Authority.

11. Review functional performance testing report for deficiencies in meeting the finalized design intent.

12. Review as-built records as required by Contract Documents and turn them over to the Commissioning Authority for inclusion in final Projects documentation.

13. Review and comment on the final commissioning report.

E. **General Contractor:**

1. Include cost for participation in the commissioning process in the Contract price.

2. Include commissioning requirements in the Mechanical, Electrical, and Controls Contracts, as well as all other sub-contractors, to ensure full cooperation of all parties in the mechanical commissioning program.

3. Ensure acceptable representation, with the means and authority to prepare and coordinate execution of the mechanical commissioning program as described in the Contract Documents.

4. Issue a statement that TAB work has been completed, and submit the final TAB reports for review.

5. Issue a statement that control systems have been calibrated.

6. Remedy deficiencies identified in verification tests.

7. Evaluate any performance deficiencies identified in the FPT report for non-conformance with Contract Documents.

F. **Applicable Mechanical Contractor:**

1. Include cost for participation in the commissioning process in the Contract price.

2. Include requirements for submittal data, O&M data, and training in each purchase order or sub-contract written.

3. Ensure cooperation and participation of specialty sub-contractors such as sheet metal, piping, refrigeration, water treatment and TAB.

4. Ensure participation of major equipment manufacturers in appropriate training and testing activities.

5. Attend Construction Phase coordination meeting scheduled by the Commissioning Authority.

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6. Assist the Commissioning Authority in all verification and functional performance tests.

7. Prepare preliminary schedule for mechanical system orientation and inspections, O&M manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up. TAB, and task completion for use by the Commissioning Authority. Update schedule as appropriate throughout the construction period.

8. Attend initial training session.

9. Conduct mechanical system orientation and inspection at the equipment placement completion stage.

10. Update Drawings to the record condition to date, and review with the Commissioning Authority.

11. Gather O&M data on all equipment, and assemble in binders as required by the Commissioning Specification. Submit to Commissioning Authority prior to the completion of construction.

12. Notify the Commissioning Authority a minimum of two weeks in advance, so that witnessing equipment and system start-up and testing can begin.

13. Notify the Commissioning Authority a minimum of two weeks in advance, of the time for start of the TAB work. Attend the initial TAB meeting for review of the TAB procedures.

14. Participate in, and schedule vendors and Contractors to participate in the training sessions as set up by the Commissioning Authority.

15. Provide written notification to the General Contractor and Commissioning Authority that the following work has been completed in accordance with the Contract Documents, and that the equipment, systems, and sub-systems are operating as required.

    a. HVAC equipment including all fans, air handling units, dehumidification units, ductwork, dampers, terminals, and all Division 23 equipment.

    b. Refrigeration equipment, pumping systems and heat rejection equipment.

    c. Fire stopping in the fire rated construction, including fire and smoke damper installation, caulking, gasketing and sealing of smoke barriers.

16. Provide a complete set of as-built records to the Commissioning Authority.

G. **Test, Adjust, and Balance Contractor:**

1. Include cost for participation in the commissioning process in the Contract price.

2. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.

3. Submit the TAB procedures to the Commissioning Authority and Design Professional for review and acceptance.

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4. Attend the TAB review meeting scheduled by the Commissioning Authority. Be prepared to discuss the procedures that shall be followed in testing, adjusting and balancing the HVAC system.

5. Participate in training sessions as scheduled by the Commissioning Authority.

6. At the completion of the TAB work, and submittal of final TAB report, notify the applicable Mechanical Contractor and General Contractor.

7. Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the Commissioning Authority for verification or diagnostic purposes.

H. **Energy Management and Control System Contractors:**

1. Include cost for participation in the commissioning process in the Contract price.

2. Review design for controllability with respect to selected manufacturers equipment:

   a. Verify proper hardware specification exists for functional performance required by Specification and sequence of operation.

   b. Verify proper safeties and interlocks are included in design.

   c. Verify proper sizing of control valves and actuators based on design pressure drops. Verify control valve authority to control coil properly.

   d. Verify proper sizing of control dampers. Verify damper authority to control air stream. Verify proper damper positioning for mixing to prevent stratification. Verify actuator vs. damper sections for smooth operation.

   e. Verify power selection of sensor ranges.

   f. Clarify all questions of operation.

3. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.

4. Provide the following submittals to the Commissioning Authority:

   a. Hardware and software submittals.

   b. Control panel construction Shop Drawings.

   c. Narrative description of each control sequence for each piece of equipment controlled.

   d. Diagrams shown all control points, sensor locations, point names, actuators, controllers and, where necessary, points of access, superimposed on diagrams of the physical equipment.

   e. Logic diagrams shown the logic flow of the system.

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f. A list of all control points, including analog inputs, analog outputs, digital inputs, and digital outputs. Include the values of all parameters for each system point. Provide a separate list for each standalone control unit.

g. A complete control language program listing including all software routines employed in operating the control system. Also, provide a program write-up, organized in the same manner as the control software. This narrative shall describe the logic flow of the software and the functions of each routine and sub-routine. It should also explain individual math or logic operations that are not clear from reading the software listing.

h. Hardware operation and maintenance manuals.

i. Application software and Project applications code manuals.

5. Verify proper installation and performance of controls/BAS hardware and software provided by others.

6. Integrate installation and programming schedule with construction and commissioning schedules.

7. Provide thorough training to pertaining personnel on hardware operations and programming, and the application program for the system.

8. Demonstrate system performance to Commissioning Authority, including all modes of system operation (e.g. normal, abnormal, emergency).

9. Provide control system technician for use during system verification and functional performance testing.

10. Provide system modifications as required.

11. Provide support and coordination with TAB Contractor on all interfaces between their scopes of work. Provide all devices, such as portable operators terminals, for TAB use in completing TAB procedures.

12. Provide adequate quantity of trend logs as required to facilitate the commissioning process.

I. **Equipment Suppliers and Miscellaneous Contractors:**

1. Include cost for participation in the commissioning process in the Contract price.

2. Provide submittals, and appropriate O&M manual section(s).

3. Attend initial commissioning meeting scheduled by the Commissioning Authority.

4. Participate in training sessions as scheduled by the Commissioning Authority.

5. Demonstrate performance of equipment as applicable.

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1.04 DOCUMENTATION

A. **Contents:** The Commissioning Authority shall oversee and maintain the development of commissioning documentation. The commissioning documentation shall be kept in three ring binders, and organized by system and sub-system when practical. All pages shall be numbered, and a table of contents page(s) shall be provided. The commissioning documentation shall include, but not be limited to, the following:

1. A detailed description of the design intent for the Project, listing operating parameters, control sequences, occupancy conditions, etc.

2. A complete description of how the HVAC system is intended to operate.

3. Approved test and balance report for the building being commissioned.

4. All accepted Shop Drawings of mechanical equipment. Shop Drawings shall be full size sheets folded as required to fit in binders.

5. All pre-functional performance test checklists, signed by indicated personnel, organized by system and sub-system.

6. All verification and functional performance test checklists/results, signed by indicated personnel, organized by system and sub-system.

7. Three copies of the operation and maintenance (O&M) manuals specified in other sections of these Specifications shall be included with the commissioning documentation. The manuals shall be incorporated in the commissioning documentation prior to commencement of O&M training required in this and other sections of the Specification. Preparation of O&M manuals shall be as specified in Section 3.07 of these Specifications.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

A. **General:** The appropriate Contractor(s) shall furnish all special tools and equipment required during the commissioning process. A list of all tools and equipment to be used during commissioning shall be submitted to the Commissioning Authority for approval. The Owner shall furnish necessary utilities for the commissioning process.

2.02 TEST EQUIPMENT - PROPRIETARY

A. **Equipment and Software:** Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of this equipment. Manufacturer shall provide the test equipment, demonstrate it's use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

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PART 3 - EXECUTION

3.01 GENERAL

A. **Pre-Construction:** A pre-construction meeting of all commissioning team members shall be held at a time and place designated by the Owner. The purpose shall be to familiarize all parties with the commissioning process, and to ensure that the responsibilities of each party are clearly understood.

B. **Completion:** The Contractor shall complete all phases of work so the systems can be started, tested, balanced, and acceptance procedures undertaken. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, etc., per the Contract Documents and related directives, clarifications, and change orders.

C. **Commissioning:** A Commissioning Plan shall be developed by the Commissioning Authority. The Contractor shall assist the Commissioning Authority in preparing the Commissioning Plan by providing all necessary information pertaining to the actual equipment and installation. If Contractor initiated system changes have been made that alter the commissioning process, the Commissioning Authority shall notify the Owner.

D. **Acceptance:** Acceptance procedures are normally intended to begin prior to completion of a system and/or sub-systems, and shall be coordinated with Division 23 Contractor. Start of acceptance procedures before system completion does not relieve the Contractor from completing those systems as per the schedule.

3.02 PARTICIPATION IN ACCEPTANCE PROCEDURES

A. **Start-Up and Test:** The Contractor shall provide skilled technicians to start-up and debug all systems within Division 23. These same technicians shall be made available to assist the Commissioning Authority in completing the commissioning program. Work schedules, time required for testing, etc., shall be requested by the Commissioning Authority and coordinated by the Contractor. Contractor shall ensure that the qualified technician(s) are available and present during the agreed upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

B. **Additional Commissioning Time:** System performance problems and discrepancies may require additional technician time, Commissioning Authority time, reconstruction of systems, and/or replacement of system components. The additional technician time shall be made available for subsequent commissioning periods until the required system performance is obtained.

C. **Qualifications:** The Commissioning Authority reserves the right to question the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians shall include expert knowledge relative to the specific equipment involved and a willingness to work with the Commissioning Authority. Contractor shall provide adequate documentation and tools to start-up and test the equipment, system, and/or sub-system.

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3.03 DEFICIENCY RESOLUTION

A. **General:** In some systems, misadjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work shall be completed under the direction of the Owner, with input from the Contractor, equipment supplier, and Commissioning Authority. Whereas all members shall have input and the opportunity to discuss, debate, and work out problems, the Owner and/or Architect shall have final jurisdiction over any additional work done to achieve performance.

B. **Time Frame**: Corrective work shall be completed in a timely fashion to permit the completion of the commissioning process. Experimentation to demonstrate system performance may be permitted. If the Commissioning Authority deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the Commissioning Authority shall notify the Owner, indicating the nature of the problem, expected steps to be taken, and suggested deadline(s) for complete of activities. If the deadline(s) pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner shall be the Contractor's responsibility.

3.04 ADDITIONAL COMMISSIONING

A. **General:** Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The Contractor(s) suppliers, and Commissioning Authority shall include a reasonable reserve to complete this work as part of their contractual obligations.

3.05 SEASONAL COMMISSIONING

A. **General:** Seasonal commissioning pertains to testing under full load conditions during peak heating and peak cooling seasons, as well as part load conditions in the spring and fall. Initial commissioning shall be done as soon as Contract work is completed, regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.

B. **Tests:** Heating equipment shall be tested during winter design extremes. Cooling equipment shall be tested during summer design extremes with a fully occupied building. Each Contractor and supplier shall be responsible to participate in the initial and alternate peak season tests of the systems as required to demonstrate performance.

3.06 ACCEPTANCE PROCEDURES

A. **Verification Tests:**

1. Scope of Verification Tests:

   a. Operating tests and checks to verify that all components, equipment, systems, sub-systems, and interfaces between systems, operate in accordance with Contract Documents. These tests are to include all operating modes, interlocks, specified control responses, specific responses to abnormal or emergency conditions, and verification of the proper response of the building automation system controllers and sensors.

   b. Verify the validity of the TAB report.

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2. Participants in Verification Tests: The Commissioning Authority shall be responsible for preparing the scope of these tests. The Commissioning Authority shall schedule the tests and assemble the commissioning team members who shall be responsible for the tests. Participating Contractors, manufacturers, suppliers, etc. shall include all costs to do the work involved in these tests in their proposals. Following is a list of tasks and supporting information that shall be required.

    a. Mechanical Contractor: Provide the service of a technician(s) who is (are) familiar with the construction and operation of this system. Provide access to the Contract Plans, Shop Drawings, and equipment cut sheets of all installed equipment.

    b. Controls Contractor: Provide the services of a controls engineer who is familiar with the details of the Project. Provide details of the control system, schematics, and a narrative description of control sequences of operation.

    c. Electrical Contractor: Provide a foreman electrician familiar with the electrical interlocks, interfaces with emergency power supply, and interfaces with alarm and life-safety systems. Provide access to the Contract Plans, and all as-built schematics of sub-systems, interfaces, and interlocks.

3. Documentation and Reporting Requirements:

    a. Provide checklists for each component, piece of equipment, system and sub-system, including all interfaces, interlocks, etc. Each item to be tested shall have a different entry line with space provided for comments. Separate checklists shall be prepared for each mode of operation. Provide space to indicate whether the mode under test responded as required or not. Also, provide space for all necessary parties to sign off on each checklist.

    b. Data sheets used in verification of the proper operation of the control system shall include each controller to be verified, the system it serves, the service it provides, and it's location. For each controller, provide space for recording the readout of the controller, the reading at the controller' sensor(s), and any comments. Also, provide space for all necessary parties to sign-off on each checklist.

    c. All test procedures and data sheets shall be submitted to the design professional for review and acceptance.

4. Instrumentation:

    a. The Commissioning Authority shall furnish all measurement instrumentation for the verification tests. All instruments will have been calibrated within the six month period prior to these tests.

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5. Verification Procedures:

   a. The Commissioning Authority shall direct and witness the verification operating tests and checks for all equipment and systems.

      1) Set the system equipment (i.e. chiller, boiler, pumps, fans, etc.) into the operating mode to be tested, i.e. normal shut down, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions.

      2) The Commissioning Authority shall inspect and verify the position of each device and interlock identified on the checklist. Each item shall be signed off as acceptable (yes), or failed (no).

      3) This test shall be repeated for each operating cycle that applies to the mechanical system being tested.

      4) Operating checks shall include all safety cutouts, alarms, and interlocks with smoke control and life safety systems during all modes of operation of the mechanical systems.

      5) If during a test an operating deficiency is observed, appropriate comments shall be added to the checklist data sheet.

      6) Verification of the interface of the monitoring and control system, and the TAB criteria shall include the following:

         a) Verify supply and return flow rates for VAV and constant volume systems in all modes of operation of the HVAC system.

         b) Verify operation of the terminal units in both heating and cooling cycles.

         c) Verify minimum outdoor air intake in all modes of operation and at minimum and maximum total air flow rates per ASHRAE Standard 62-89 Equation 6-1.

         d) Verify building pressurization.

         e) Verify total exhaust air flow, and total outdoor air intake.

      7) Verification of the proper responses of monitoring and control system controllers and sensors shall be as follows:

         a) For each controller or sensor, record the indicated monitoring and control system reading and the test instrument reading.

         b) If the initial test indicates that the test reading is outside of the control range of the installed device, the calibration of the installed device shall be checked and adjusted as required. The deficient device shall be re-tested and the results recorded on the checklist data sheet. If the device fails it shall be replaced.

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b. The Commissioning Authority shall direct and witness the field verification of the final TAB report.

1) The Commissioning Authority shall select, at random, 10 percent of the report data for verification.

2) The TAB Contractor shall be given sufficient advance notice of the date of field verification. However, they shall not be informed in advance of the data points to be verified. The TAB Contractor must use the same instruments (by model and serial number) that were used when the original data were collected.

3) Failure of an item is defined as:

a) For all readings other than sound, a deviation of more than 10 percent.

b) For sound pressure readings, a deviation of 3 decibels. (Note: variations in background noise must be considered).

4) A failure of more than 10 percent of the selected items shall result in the rejection of the final TAB report.

c. If deficiencies are identified during verification, the General Contractor must be notified, and action taken to remedy the deficiency. The final tabulated checklist data sheets shall be reviewed by the Design Professional and the Commissioning Authority, to determine if verification is complete, and the operating system is functioning in accordance with the Contract Documents.

B. **Functional Performance Testing:**

1. Scope of Functional Performance Testing:

a. Functional performance tests shall determine if the HVAC system is providing the required cooling and heating services in accordance with the final design intent. They shall also determine the installed capacity of the cooling and heating plant and heat transfer components. Following is a list of test examples:

1) Determine capability of chilled water system to deliver chilled water at the design supply temperature, and required rate of flow.

2) Determine capacity of electric heating system to deliver heating at the design temperature.

3) Determine the ability of the HVAC unit to deliver the cooling and/or heating services to the distribution system, at the design supply air temperature, required static pressure, and proper outside air ventilation rate.

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2. Submittals:

   a. Detailed procedures for each series of tests shall be submitted to the Commissioning Authority for review and acceptance. The procedures shall include samples of the data sheets that will be part of the reports.

3. Participants in Functional Performance Tests:

   a. Participants in the functional performance tests shall be the same as those listed in the verification tests.

4. Instrumentation:

   a. In addition to the instrumentation requirements detailed under verification, the Commissioning Authority may need to provide data acquisition equipment to record data for the complete range of testing.

5. Functional Performance Test Procedures:

   a. The Commissioning Authority shall supervise and direct all functional performance tests.

   b. For each test, the Commissioning Authority shall install the measuring instruments and logging devices to record test data for the required test period. The instrumentation shall monitor and record all operating conditions to allow for complete evaluation of the test results.

   c. Measurements will be required to allow for calculation of total capacity of the system for each mode of operation under test.

6. Documentation and Reporting Requirements:

   a. All measured data, data sheets, and a comprehensive summary, describing the operation of the HVAC system at the time of testing shall be submitted to the Commissioning Authority.

   b. A preliminary functional performance test report shall be prepared by the Commissioning Authority and submitted to the Design Professional for review. Any identified deficiencies need to be evaluated by the Design Professional and General Contractor to determine if they are part of the Contractor's or sub-contractor's contractual obligations. Construction deficiencies shall be corrected by the responsible Contractor(s), and the specific functional performance test repeated.

   c. If it is determined that the HVAC system is constructed in accordance with the Contract Documents, and the performance deficiencies are not part of the Contract Documents, the Owner must decide whether any required modifications needed to bring the performance of the HVAC system up to the finalized design intent shall be implemented, or if the test shall be accepted as submitted. If corrective work is performed, the Owner shall determine if a portion or all required functional performance tests should be repeated and a revised report submitted.

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3.07 OPERATING AND MAINTENANCE MANUAL

A. **Contents**: The operating and maintenance manual shall consist of a sturdy binder with 8-1/2 x 11 inch sheets containing the following major sections:

1. System Descriptions:

a. Each major system shall be described, type-written, in general terms, including major components, interconnections, theory of operation, theory of controls, unusual features and major safety precautions. This information should correlate with information provided in the manufacturers' instructions book. This section shall include, but not be limited to, the following data:

1) Detailed description of each system and each of it's components showing piping, valves, controls, and other components, with diagrams and illustrations where applicable.

2) Wiring and control diagrams with data to explain detailed operation and control of each component.

3) Control sequences describing start-up, all modes of operation, and shutdown.

4) Corrected Shop Drawings.

5) Approved product data including all performance curves and rating data.

6) Copies of approved certifications and laboratory test reports (where applicable).

7) Copies of warranties.

b. System diagrams, described in 3.07, B, 2, following, shall be incorporated in the appropriate systems descriptions. These should be reduced in size or folded to usefully fit into the manual.

2. Operating Instructions:

a. Condensed, type-written, suitable for posting, instructions shall be provided for each major piece of equipment. Where more than one (1) common unit is installed, one instruction is adequate. The instructions shall provide procedures for:

1) Starting up the equipment/system.
2) Shutting down the equipment/system.
3) Operating the equipment in emergency or unusual conditions.
4) Safety precautions.
5) Trouble shooting suggestion.
6) Other pertinent data applicable to the operation of particular systems or equipment.

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b. The instructions shall be suitable for posting adjacent to the equipment concerned. The Contractor shall provide instructions for:

1) Electric heating equipment.
2) Hydronic distribution systems, including pumps.
3) Air handling units and exhaust fans.
4) DDC control systems.
5) Fan powered mixing boxes.
6) Emergency generating plans.
7) Domestic water pumps.
8) Variable frequency drives.
9) Other specialized or uncommon equipment.

3. Ongoing and Preventive Maintenance:

a. Condensed, type-written procedures for recommended ongoing and preventive maintenance actions shall be provided for each category of equipment/system listed in 3.07, A, 2 above. The information shall include, but not be limited to, the following:

1) Maintenance and overhaul instructions.

2) Lubricating schedule including type, grade, temperature, and frequency range.

3) Parts list, including source of supply and recommended spare parts.

4) Name, address, and 24 hour telephone number of each subcontractor who installed equipment and systems, and local representative for each type of system.

5) Other pertinent data applicable to the maintenance of particular systems or equipment.

b. These recommended preventive maintenance actions shall be categorized by the following recommended frequencies:

1) Weekly
2) Monthly
3) Quarterly
4) Semi-Annual
5) Annual
6) Other

B. **Posted Operating Instructions and Diagrams:**

1. Operating Instructions:

a. Copies of operating instructions provided in the operating manual (3.07, A above) shall be provided by Division 23 Contractors and shall be posted in the near vicinity of each piece of applicable equipment. The instructions shall be mounted neatly where they can be easily read by operating personnel. Instructions mounted outdoors shall be suitably protected from weather.

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2. Posted System Diagrams:

   a. Simplified one (1) line diagrams of the systems listed shall be developed and transcribed on transparent "D" sized erasable sepia film and posted neatly under Plexiglas in the main or most appropriate equipment room for easy reference by operating and maintenance personnel. These Drawings shall be done in a professional manner which is acceptable to the Maintenance Division staff. The diagrams shall show each component, including all valves installed in the system, with name and identifying number. If space does not permit valve numbers on the diagrams, valve charts shall be provided. Explanatory notes, where needed, shall be provided.

      1) HVAC controls diagram.
      2) Hydronic distribution system.
      3) Electric heating system.
      4) Air handling/ventilation system.
      5) Domestic water system.
      6) Emergency power generation.
      7) Other systems as applicable.

   b. These diagrams shall be suitable for reduction in size and use in the operating manual system descriptions previously covered.

3.08 OPERATING AND MAINTENANCE TRAINING

A. **Instruction:** The applicable Mechanical Contractor, and appropriate subcontractors, shall provide comprehensive operating and maintenance instruction on building systems prior to delivery. The instruction shall include classroom instruction delivered by competent instructors based upon the contents of the operating manual. Emphasis shall be placed upon overall systems diagrams and descriptions, and why systems were designed as they were. This overall systems instruction shall preferably be delivered by the consulting engineers. The classroom instruction shall also include detailed equipment instruction by qualified manufacturer representatives for all equipment listed in 3.07.A.2.b, for which operating instructions are provided. The manufacturer representative training shall emphasize operating instructions, and preventive maintenance as described in the operating manual. At a minimum, the training sessions shall cover the following items:

   1. Types of installed systems.

   2. Theory of operation:

      a. Design intent.
      b. Occupied vs. unoccupied or partial occupancy.
      c. Seasonal modes of operation.
      d. Emergency conditions and procedures.
      e. Comfort conditions.
      f. Indoor air quality.
      g. Energy efficiency.
      h. Other issues important to facility operation.

   3. System operations.

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4. Use of control system:

   a. Sequence of operation.
   b. Problem indicators.
   c. Diagnostics.
   d. Corrective actions.

5. Service, maintenance, diagnostics and repair.

6. Use of reports and logs.

7. Troubleshooting, investigation of malfunctions, and determining reasons for the problem.

B. **Classroom Training:** Each classroom training period shall be followed by an inspection, explanation and demonstration of the system concerned by the instructors. All equipment listed in 3.07, A, shall be started up and shut down, with the exception of sprinkler systems.

C. **Organization:** The Contractor shall be responsible for organizing, arranging, and delivering this instruction in an efficient and effective manner on a schedule agreeable to the Owner.

D. **Agenda:** The Contractor shall provide, at or before substantial completion, a proposed agenda and schedule of the above training for approval by the Commissioning Authority and the Owner.

3.09 ACCEPTANCE-PHASE PROCEDURES

A. **Overview:**

1. A description of the acceptance-phase procedures is critical to the commissioning process. This discussion is applicable to a typical comprehensive commissioning process. Verification testing will determine if the HVAC system is operating in accordance with Contract Documents. Functional performance testing (FPT) will determine if the HVAC system is performing in accordance with the finalized design intent (as revised in the design process and approved by the Owner). These procedures may start once the applicable Mechanical Contractor has been notified the General Contractor that the HVAC system installation has been completed and the Design Professional has accepted the TAB report from the Testing, Adjusting, and Balancing Contractor.

2. Typically verification tests are directed and witnessed by the Commissioning Authority. If deficiencies are identified during verification, the General Contractor must be notified and action taken to remedy the deficiency. Once verification is completed and the operating system is functioning in accordance with the Contract Documents, the Commissioning Authority can issue the verification report to the Owner and HVAC Design Professional for review. Once satisfied with the completion of verification, the HVAC Design Professional can issue the Certificate of Readiness, allowing Functional Performance Testing to begin. The Commissioning Authority should supervise and direct the Functional Performance Tests. Performance deficiencies (as opposed to construction punch list deficiencies), at the Owner's discretion, should be corrected and the tests repeated. The verification test checklists and the data and evaluation of the final FPT tests should be made part of the Commissioning Authority's commissioning report.

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3.10 VERIFICATION

A. **Checks/Tests:** Verification is composed of a full range of checks and tests to determine that all components, equipment, systems, and interfaces between systems (e.g. emergency, fire, and life safety) operate to accordance with Contract Documents. This includes all operating modes, interlocks, control responses, and specific responses to abnormal or emergency conditions. Verification of the proper operation of the control system also includes verifying the interface of the control system with the TAB criteria and the response of monitoring and control system controllers and sensors. Verification of operating modes, etc. can be done concurrently with controllers and sensors. Verification will also validate the test and balance (TAB) report.

3.11 FUNCTIONAL PERFORMANCE TESTING

A. **General:** FPT will determine if the HVAC system is providing the required cooling, ventilating, and heating services in accordance with the finalized design intent. FPT will also determine the as-built installed capacity of the cooling and heating plant and the heat transfer components.

B. **Part Load:** In most cases, FPT will be completed at less than full load conditions in the heating, ventilation, and cooling modes. For this reason, specifications must include the requirements for part-load performance data to be submitted by the manufacturers of all heat transfer equipment. This also applies to system curves for pumps that operate with variable frequency drives (VFD) and fans at partial loads.

C. **Review and Acceptance:** A preliminary FPT report will be prepared by the Commissioning Authority and submitted to the Design Professional for review. Any identified performance deficiencies need to be evaluated by the Design Professional and the General Contractor to determine the cause and if they are part of the Contractor's contractual obligations. It may not be possible to correct these deficiencies without major modifications to the HVAC system.

1. If it is determined that the HVAC system is constructed in accordance with Contract Documents and that the performance deficiencies are not part of the Contract Documents, the Owner must decide whether any required modifications to bring the performance of the HVAC system up to the finalized design intent will be implemented or if the FPT will be accepted as submitted. If corrective work is performed, a portion of or all of the FPT should be repeated and a revised report submitted.

3.12 SAMPLE ACCEPTANCE-PHASE PROCEDURE

A. This example contains test procedures to be included in the updated Commissioning Plan prepared during the construction phase. This list can be expanded or modified as needed to suit the specifics of the Project. Comments are in italics.

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B. **Verification Tests:**

1. Scope of Verification Tests:

   a. Operating tests and checks to verify that all components, equipment, systems, subsystems, and interfaces between systems operate in accordance with Contract Documents. Tests to include all operating modes, all specified responses, all interlocks, all control responses, all specific responses to abnormal or emergency conditions, and verification of the proper response of the monitoring and control system controllers and sensors.

   b. Verify the validity of the test and balance (TAB) report.

2. Participants in Verification Tests: Note: The list included here is not intended to be complete. The participants will be determined by the type of HVAC system to be tested and the requirements of the facility.

3. The Commissioning Authority (C.A.) will be responsible for preparing the scope of these tests. The C.A. will schedule the tests and assemble the commissioning team members who will participate. The participating Contractors, manufacturers, suppliers, etc., will include all costs to do work involved in these tests in their proposal. Following is a list of tasks and supporting information that will be required.

   a. Controls Contractor: Provide services of a controls engineer who is familiar with the details of this Project. Provide details of the control system, schematics, and a narrative description of the controls sequence of operation at the job site at the time of the tests.

   b. Testing Contractor: Provide services of an experienced testing technician and instrumentation required for each of the tests.

   c. Electrical Contractor: Provide a foreman electrician who is familiar with the electrical interlocks, interfaces with emergency power supply, interfaces with alarm and life safety systems. Provide the Contract Drawings and all as-built schematics of subsystems, interfaces, and interlocks at the job site at the time of the tests.

   d. Applicable Mechanical Contractor(s): Provide the services of an engineer and service personnel who are familiar with the construction and operation of this system. Make available the Contract Plans, Shop Drawings, and equipment cut sheets of all equipment that are involved at the job site at the time of the tests.

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4. Verification Documentation Requirements of the Testing Contractor: In addition to the Contract Documents detailed in the requirements for each of the participants, the following documentation will be required for complete execution of the tests.

   a. Provide checklists for each component, equipment, system, and subsystem, interface, interlock, etc. Each item to be checked shall have a different entry line with space provided for comments. Separate checklists shall be prepared for each mode of operation. Provide space for indicating whether the mode under test responded as required or not. Provide additional space for the test technician and the C.A. to initial each item.

   b. Data sheets used in the verification of the proper operation of the control system will include each controller to be verified, the system it serves, the service it provides, and its location. For each controller, provide space for recording the readout of the controller, the reading at the controller's sensor(s), and comments. Provide space for the C.A. to sign off each data sheet.

   c. Data sheets used in verification of the validity of the TAB report shall be similar to the TAB data sheets used in the TAB report, except an additional column shall be provided to record the verification test data. Provide space for the C.A. to sign off each data sheet.

   d. All test procedures and data sheets shall be submitted to the design professional for review and acceptance.

5. Instrumentation: The Testing Contractor shall furnish all measurement instrumentation for the verification tests. All instruments will be calibrated within the six-month period prior to the verification tests. Diagnostic equipment is to be provided by the appropriate Contractor. Note: If the Testing Contractor is also the TAB Contractor, then the same instruments that were used in the TAB procedures will be used in these tests. However, the same requirements for calibration will still apply.

   a. To be provided by the Testing Contractor:

      1) Airflow-measuring equipment:

         a) Flow hood meter capable of measuring the airflow rates at diffusers and registers.
         b) Pitot tubes (sizes as required).
         c) Differential pressure instruments capable of accurate measurements from as low as 0.0005 in w.c.
         d) Static pressure-sensing tips and any required sensing devices.
         e) Smoke tubes, smoke candies, etc., as required to demonstrate patterns of air distribution.

      2) Water flow measurement equipment:

         a) Differential pressure instruments (ranges as required).
         b) Mass and velocity flowmeters (capacities and type as required).
         c) Test quality pressure gauges.

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3) Temperature and relative humidity measurement equipment:

a) Outside ambient room, and duct air temperature and RH sensors or transmitters.
b) Liquid insertion or surface temperature sensors or transmitters.
c) Dew-point temperature sensors or transmitters.

4) Electric demand measurement equipment:

a) Ammeter, voltmeter, and kW recorders.
b) kW electric demand meter or transmitter system.
c) Power factor meter or transmitter.

5) Recorders or data loggers, as required, may be utilized to collect the measured data provided by the instruments above.

b. To be provided by the Controls Contractor:

1) Access to control system to compare data and make adjustments as required.

c. To be provided by the Electrical Contractor:

1) Continuity testing and meter or other related diagnostic equipment.

d. To be provided by the applicable Mechanical Contractor:

1) All tools and devices to make adjustments as required.

6. Verification Procedures:

a. Operating tests and checks.

1) The C.A. will direct and witness verification operating tests and checks.

2) Set the system equipment e.g. chiller, boiler, HVAC unit, exhaust blowers, into the operating mode to be tested, e.g. normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions.

3) Each operating cycle shall be tested after it has been running for a period of three hours and it is operating in a steady-state condition.

4) The C.A. and the Testing Contractor's technician will inspect and verify the position of each device and interlock that is identified on the checklist. Each item shall be signed off as acceptable (yes) or failed (no).

5) This test will be repeated for each operating cycle that applies to the HVAC system being tested.

6) Operating checks shall include all safety cutouts, alarms, and interlocks with smoke control and life safety systems during all modes of operation of the HVAC system.

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7) If, during a test, an operating deficiency is observed, appropriate comments shall be added to the checklist data sheet.

8) Verification of the interface of the monitoring and control system and the TAB criteria shall include the following:

a) Verify flow rates for air and water systems (e.g. supply, return, and exhaust) in all modes of operation of the HVAC systems.

b) Verify operation of the terminal units in all modes of operation.

c) Verify minimum outdoor air intake in all modes of operation and at minimum and maximum total airflow rates.

d) Verify building pressurization.

e) Verify total exhaust airflow and total outdoor air intake (O.A.I.).

f) Verify operation of the IAQ monitoring system.

g) Failure to pass the verification test is as defined in "Verification of the Final TAB Report" below.

h) The deficiency shall be corrected by the responsible Contractor(s) and the condition retested and results recorded on the checklist data sheet.

9) To verify the proper response of monitoring and control system controllers and sensors:

a) For each controller or sensor, record the indicated monitoring and control system reading and the test instrument reading.

b) If the initial test indicates that the test reading is outside the control range of the installed device, the calibration of the installed device shall be checked and adjusted as required. The deficient device shall be retested and the results recorded on the checklist data sheet.

b. Verification of the Final TAB Report:

1) The C.A. will direct and witness the field verification of the final TAB report.

2) The C.A. will select at random a percentage of the report data for verification. Report data are defined as the air velocity at a specific outlet, air or water flow rate, indicated differential pressure, electrical or sound measurement, or any other measurement that is applicable.

3) If the Testing Contractor is also the Test and Balance Contractor, he/she shall be given sufficient advance notice of the date of field verification. However, he/she shall not be informed in advance of the data points to be verified. The Test and Balance Contractor must use the same instruments (by model and serial number) that were used when the original data were determined.

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4) Failure of an item is defined as the following:

a) For all readings other than sound, a deviation of more than 10%.

b) For sound pressure readings, a deviation of 3 decibels. Variations in background noise must be considered.

5) A failure of more than 10% of the selected items shall result in the failure of acceptance of the final TAB report.

6) Failure of the final TAB report shall require the Testing and Balancing Contractor to complete the following work at no additional cost.

a) Any system failing the verification procedure must be rebalanced.
b) New total system TAB reports must be provided.
c) Field verification of the new TAB report must be performed.

c. If deficiencies are identified during verification the General Contractor must be notified and action taken to remedy the deficiency. The final tabulated checklist data sheets shall be reviewed by the HVAC design professional and the C.A. to determine if verification is completed and the operating system is functioning in accordance with the Contract Documents. Once verification is completed, the C.A. shall provide a verification report to the Owner and HVAC design professional for review. Once satisfied with the completion of verification, the HVAC design professional shall issue the Certificate of Readiness allowing functional performance testing to begin.

C. **Functional Performance Testing (FPT):**

1. Scope of Functional Performance Testing:

a. FPT will determine if the HVAC system is providing the required cooling and heating services in accordance with the finalized design intent. It will also determine the as-built installed capacity of the cooling and heating plant and the heat transfer components.

b. Specific Tests to Be Conducted: (The following is a representative list of test examples.)

1) Determine capacity of boiler (or other heating source) and associated equipment to deliver heating service at the design temperature, pressure and rate of flow.

2) Determine capability of chiller and associated primary and secondary equipment to deliver chilled water at the design supply temperature and required rate of flow.

3) Determine the ability of the HVAC unit to deliver the cooling and/or heating services to the distribution system at the design supply air temperature, required static pressure, and proportion of outside air ventilation rate.

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2. Submittals:

   a. Detailed procedures for each series of tests shall be submitted to the C.A. for review and acceptance by the design professional. The procedures shall include sample of the data sheets that will be part of the reports.

3. Participants in FPT: (Please see participants in verification tests in Section A, 2 above.)

4. Instrumentation: In addition to the instrumentation requirements detailed in verification, the Testing Contractor will provide data acquisition equipment to record the data for the complete range of testing. (Please see instrumentation, Section A, 4 above.)

5. FPT Procedures:

   a. The C.A. will supervise and direct FPT.

   b. For each test, the Testing Contractor will install the measuring instruments and logging devices to record the test data for the required test period. The instrumentation shall meter and record all operating conditions to allow for complete evaluation of the test results.

   c. Measurements will be required to allow for calculation of total capacity of the system for each mode of operation under test. If a cooling test is conducted during the heating season, it will be repeated during the next cooling season.

   d. For individual room cooling tests, the Testing Contractor shall provide electric room heaters to simulate design full load load conditions.

6. FPT Documentation and Reporting Requirements:

   a. All measured data, data sheets, and a comprehensive summary describing the operation of the HVAC system at the time of the test will be submitted to the C.A. by the Testing Contractor. If there are deviations in performance from Contract Documents or the finalized design intent, a description and an analysis shall be included.

   b. A preliminary FPT report will be prepared by the C.A. and submitted to the design professional for review. Any identified performance deficiencies need to be evaluated by the design professional and the General Contractor to determine if they are part of the Contractor's or subcontractor's contractual obligations. Construction deficiencies will be corrected by the responsible Contractor(s) and the specific FPT repeated.

   c. If it is determined that the HVAC system is constructed in accordance with Contract Documents and that the performance deficiencies are not part of the Contract Documents, the Owner must decide whether any required modifications to bring the performance of the HVAC system up to the finalized design intent will be implemented or if the FPT will be accepted as submitted. If corrective work is performed, the Owner will determine if a portion or all of the functional performance testing should be repeated and a revised report submitted.

END OF SECTION

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SECTION 23 09 13

INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 - GENERAL

1.01 SUMMARY

A. **Section Includes:** Include labor, material, equipment, and accessories to furnish and install instrumentation and control devices for HVAC.

B. **Related Sections:**

1.	Section 23 00 00:	Heating, Ventilating, and Air-Conditioning (HVAC) - General Requirements
2.	Section 23 05 29:	Hangers and Supports for HVAC Piping and Equipment
3.	Section 23 05 48:	Vibration and Seismic Controls for HVAC Piping and Equipment
4.	Section 23 05 93:	Testing, Adjusting, and Balancing for HVAC
5.	Section 23 07 00:	HVAC Insulation
6.	Section 23 09 23:	Direct-Digital Control System for HVAC
7.	Section 23 09 93:	Sequence of Operations for HVAC Controls
8.	Section 23 33 00:	Air Duct Accessories
9.	Section 23 36 00:	Air Terminal Units
10.	Section 23 37 00:	Air Outlets and Inlets
11.	Section 23 75 13:	Dedicated Outside Air System (DOAS) Units

1.02 REFERENCES

A. **American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE)**

B. **American Society of Mechanical Engineers (ASME)**

C. **American National Standards Institute (ANSI)**

D. **Canadian Standards Association (CSA)**

E. **Environmental Protection Agency (EPA)**

F. **Federal Communications Commission (FCC)**

G. **International Standards Organization (ISO)**

H. **National Electrical Manufacturers Association (NEMA)**

I. **National Fire Protection Association (NFPA)**

J. **Occupational Safety and Health Act (OSHA)**

K. **Underwriters Laboratory (UL)**

L. **Underwriters Laboratory Canada (ULC)**

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1.03 DEFINITIONS

A. **Actuator Repeatability:** The ability of an actuator to return to a previous position without error.

B. **Adjustable Angle of Rotation (AAR):** The adjustable portion of the angle of rotation as measured in degrees.

C. **Angle of Rotation (AR):** Rotation measured in degrees starting from 0 degrees.

D. **Anti Rotation Strap:** A flexible metal strap designed to be easily field formed to different ductwork configurations. Provides up and down lateral movement of the actuator without fatigue to either the sheet metal fastening device or mounting assembly.

E. **Cold Weld V Clamp:** A device fastening two objects. The bonding of two metals by metal migration while under compression of a serrated V shaped mechanical clamp.

F. **Controller Actuator:** A device consisting of actuator and internal electronic microprocessor circuitry designed to provide control decisions and actuation in a single housing.

G. **Direct Coupled Mounting:** An actuator directly mounted to a shaft. Not requiring linkage to directly deliver torque.

H. **Direct Coupled Mounting with Linkage Assist:** An actuator directly mounted to one shaft with linkage to deliver torque to another shaft.

I. **Direct Coupled Mounting with Linkage Drive:** An actuator not able to be directly mounted to a shaft. Linkage delivers torque directly to shaft.

J. **Electronic Overload Protection:** Protection against actuator burnout using an internal current limiting circuit or digital motor rotation sensing circuit.

K. **Floating Actuator:** Actuation where only general positioning is required. Control signal commands generate power open, no movement, and power close commands of varying time duration to move the actuator to a general position.

L. **Guaranteed Minimum Torque (GmT):** Torque guaranteed in inch pounds at worst case ambient temperature, voltage conditions, and anticipated electronic component aging over the life of all components.

M. **High Torque Actuator:** An actuator designed to deliver 200 - 400 inch pounds of torque.

N. **Intelligent Actuator:** A device consisting of actuator and internal electronic microprocessor circuitry designed to provide two way digital communication and actuation in a single housing.

O. **Linear Actuator:** Actuation where modulation to any position along a straight line is required.

P. **Low Torque Actuator:** An actuator designed to deliver 25 - 75 inch pounds of torque.

Q. **Medium Torque Actuator:** An actuator designed to deliver 75 - 200 inch pounds of torque.

R. **Mini Torque Actuator:** An actuator designed to deliver 10 - 25 inch pounds of torque.

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S. **On/Off Actuator:** Actuation where only two positions are required. Control contacts generate power open and power close commands.

T. **On/Off Spring Return Actuator:** Actuation where only two positions are required. Control contacts generate a power open or power close command. An internal safety spring returns the actuator to its original position upon release of control contact signal.

U. **Proportional Actuator:** Actuation where modulation to any position in the angle of rotation is uniform to the control input signal.

V. **Proportional Control Input Signal:** A control signal generated by a computer or other device. Proportional signals are 0 - 10 volts DC, 2 - 10 volts DC, 4 - 20 milliamp, 0 - 20 volts phase cut, 135 ohm, and pulse width. Control input signal is linear to the angle of rotation.

W. **Proportional Spring Return Actuator:** Actuation where modulation to any position in the angle of rotation is required. Upon removal of actuator power the actuator safety spring returns to an open or closed position.

X. **Pulse Width Control Input Signal:** A timed contact closure generated by a computer or other device. Time ranges vary from .1 second to 25.5 seconds per pulse depending on the control manufacturer.

Y. **Running Time (RT):** Time in seconds required for an actuator to travel under power in one direction.

Z. **Spring Return Time (SRT):** Time in seconds required for an actuator to travel under mechanical power in one direction.

AA. **Ultra High Torque Actuator:** An actuator designed to deliver 400 - 1330 inch pounds of torque.

1.04 SUBMITTALS

A. **Shop Drawings:** Submit a portfolio, minimum of 5 copies, showing actuator units to be used indicating equipment to be served for approval by Engineer.

1.05 QUALITY ASSURANCE

A. **Regulatory Requirements:**

1. State Building Code
2. Local Codes and Ordinances
3. Local Authority having jurisdiction

B. **Supplier Requirements:**

1. Where two or more units of the same class of equipment are required, the units shall be the products of a single manufacturer.
2. Mixing and matching of various manufacturers' like or similar components shall not be permitted.
3. The actuator manufacturer shall have trained representatives available to provide ongoing training for field technicians, as well as operating personnel.

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4. The actuator manufacturer shall have a local district manager, employed and trained directly by the manufacturer. The actuator manufacturer shall have technical staff available for design and application assistance.

5. The actuator manufacturer shall be certified under ISO 9001 and have a minimum of 15 years verifiable experience in the design and application of Electronic Direct Coupled Actuators.

1.06 WARRANTY

A. **Actuators:** Actuator manufacturer shall provide a minimum two year warranty on all parts.

1. The warranty period shall begin at the date of substantial completion of the project.

2. The manufacturer shall provide to the end user an analysis of the defect found, upon written request.

1.07 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. **Hydronic Piping:** Installation of control valves, flow switches, temperature sensor wells, gauge taps, flow meters.

B. **Air Flow Measuring Stations:** Installation of duct mounted air flow measuring stations.

C. **Ductwork Accessories:** Installation of automatic dampers. To include assembly of multiple section dampers with required interconnecting linkages, shafts and brackets and extend the required number of shafts through the ducts for externally mounted damper motors. Jack shafts will be assembled with sealed roller ball bearings of stainless steel construction.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Acceptable Manufacturers for Actuators:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Belimo
2. Invensys
3. Johnson Controls
4. Siemens
5. Bray

B. **Acceptable Manufacturers for Control Valve Assembly:** Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:

1. Belimo
2. Invensys
3. Johnson Controls
4. Siemens
5. Bray

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2.02 ACTUATORS

A. **General:** Electronic direct coupled actuation shall be provided. Actuators shall be Underwriters Laboratories Standard 873 listed. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 2 year unconditional manufacturer's warranty from date of substantial completion. Actuator shall have electric overload protection.

1. Modulating actuators shall have digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Actuators shall have "V" bolt design with associated "V" shaped toothed cradle attaching to the shaft defined as a "cold weld" for maximum strength and eliminate slippage. Single bolt or set screw type fasteners are not acceptable. Actuators shall be manufactured by Belimo.

B. **Fail Safe Application:** Following a power interruption, spring return actuators shall respond to the controlling device without any time delay or reinitialization function. All fail safe applications will use a mechanical spring that is immediately operable and has a documented rating for a minimum of 60,000 full stroke cycles. Spring return actuators shall have a "V" clamp assembly of sufficient size to be directly mounted on an internal jackshaft of up to 1.05 inches when the damper is constructed in this manner. Spring return actuators of 120V and 230V or with built in auxiliary switches shall be UL approved as "Double Insulated" devices and shall be constructed so an electrical ground connection is not required to meet agency listings. Spring Return actuators shall have a "breathable membrane" to compensate for pressure differential allow for 100% relative humidity in the airstream.

1. Low Limit Trip: Upon low limit trip, power to the actuator must be interrupted to allow the spring to close the damper - utilizing the control signal to power the actuator closed will not be accepted.

2. Fail Safe Application Schedule:

Heating Valves; Fail Open Applications (Spring Return Required)
All Ventilation Units with an Outside Air Source
Air Handlers
Rooftop Units
Energy Recovery Units
Cabinet Unit Heaters

Heating Valves; Floating Point Applications (Spring Return not Required)
Glycol Fed Reheat Coils
Glycol Fed VAV Boxes
Unit Heaters
Fintube Radiation, Radiant Panels and Convectors

C. **Torque and Sizing:** Damper actuators shall be sized to provide a minimum of 5 inch-pounds torque per square foot of damper face area.

D. **Actuator Housings:** Damper actuators shall be provided with proper weather, corrosive, or explosion-proof type housings as required by application.

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2.03 CONTROL VALVE ASSEMBLIES - BALL VALVES

A. **Ball Valve Bodies:** All ball valves used for modulating or floating tri-state control shall be furnished with a stainless steel ball & stem and reinforced TFE seats and seals and female NP threads.

1. Two way bronze bodies up to 3 inches shall be rated for 600 PSI WOG, cold, non-shock service.

2. Three way bronze bodies up to 2 inches shall be rated for 400 PSI WOG, cold, non-shock service.

3. The valves shall have a blow out proof stem design. Each valve shall be tested by the valve manufacturer, air under water, at each end of travel. The stem packing gland shall be adjustable, to compensate for wear. Over-ride handles when provided shall have a hole for tagging purposes.

B. **Valve/Actuator Mounting:** All ball valve bodies shall be thermally separated from the actuator mounting bracket with high temperature materials rated for continual use at greater than 350 Degree F.

1. Additional thermal separators shall also be provided between the mounting bracket and electronic valve actuators to allow complete free air movement around the actuator, to minimize heat transfer and condensation.

a. Valve assemblies without both sets of stand-offs described above shall not be acceptable.

C. **Application:**

1. Hot or Chilled Water: Ball valves shall be acceptable for two position or modulating control of hot or chilled water (or glycol solution) as long as the sizing of the valve takes into consideration both the pressure drop of the coil and the additional pressure drop incurred when reducing down from the line size to the control valve. (Adjustment of the Cv for the Piping Geometry Factor, Fp) The Manufacturers recommendations shall be followed with regard to mounting, locating insulating and applying the products.

D. **Valve Actuator:** See Actuator Specification for details.

2.04 CONTROL VALVE ASSEMBLIES - BUTTERFLY VALVES

A. **Electronic Butterfly Valve Specifications:**

1. Valve sizes range form 2 inch through 20 inches and shall be rated at ANSI 150 pressure rating for hydrostatic requirements.

2. Valve shall be wafer, semi-lugged or full-lugged. If lugged, the valves shall be drilled and tapped for isolation and removal of downstream piping. Flanges shall meet ANSI 125 and 150 standards.

3. Valves shall be factory tested to 110 percent of specified pressure rating.

4. Valves shall have close tolerance, double "D" connection that drives the valve disc which eliminates stem retention components being exposed to the line media, such as disc screws and taper pins, which commonly result in leak paths, corrosion and vibration failures.

5. The disc casting shall be spherically machined and hand polished to provide a bubble-tight shut off, minimum torque, and longer seat life. The stem bushing shall be non-corrosive, heavy duty acetal to absorb actuator side thrusts. The stem seal shall be a double "U" cup seal designed to self-adjust and gives positive sealing in both directions.

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6. The stem shall be retained in the body by a Stainless Steel "Spirolux" retaining ring which prevents accidental removal of stem during field service.

7. The primary stem seals shall be achieved by an interference fit of the molded seat flat with the disc hub. The secondary stem seal shall be achieved by an interference fit because the stem diameter is greater than seat's stem hole diameter. The seals shall prevent the line media from coming in contact with the stem or body.

8. The seat shall be a "tongue and groove" seat. The resilient seat shall provide complete isolation of flowing media from the body by a totally encased design.

   a. The seat shall be designed to seal with slip-on or weld-neck flanges. The seat shall feature a molded o-ring which eliminates the requirement of flange gaskets.

B. **Valve/Actuator Mounting:**

1. The valve shall have an extended neck to allow for 2 inch of piping insulation and easy mounting of actuators.

C. **Butterfly Valves Actuators:** See Actuator Specification for details.

2.05 CONTROL VALVE ASSEMBLIES - GLOBE VALVES

A. **Electronic Globe Valve Specifications:**

1. Two and Three Way Screwed Valves:

   a. Valves 1/2 inch through two inches shall be bronze body, NPT screw type, and shall be rated for ANSI Class 250 working pressure. The operating temperature range shall be 40 to 250 Deg.F.

      1) Valve stems shall be stainless steel. Valve plugs shall be brass for water service and brass or stainless steel for steam service, depending on temperature and pressure requirements.

      2) Stem packing shall be spring loaded EP-V rings or EPT.

   b. Valves 1/2 inch through 1 1/4 inch shall be rated for 25 PSI differential for water and 15 PSI differential for steam.

   c. 2-way valves, 1 1/2 inch and 2 inch, shall be rated for 35 PSI differential for water applications and 50 PSI differential for steam applications.

      1) Flow type for 2-way valves shall be equal percentage or modified equal percentage for water applications, modified equal percentage for steam applications.

   d. 3-way valves, 1 1/2 inch and 2 inch, shall be rated for 30 PSI differential.

      1) Flow type for 3-way valves shall be linear.

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2. Two and Three Way Flanged Valves:

   a. Valves 2 1/2 inch through 6 inches shall be cast iron or cast carbon steel, flanged, and rated for ANSI Class 125 working pressure. The operating temperature range shall be 40 to 300 Degrees F.

      1) Valve stems shall be stainless steel. Valve plugs shall be brass. Stem packing shall be spring loaded EP-V rings.

      2) Flow type for two way valves shall be equal percentage or modified equal percentage for water applications.

      3) Flow type for three way valves shall be linear.

   b. 2-way valves, 1 1/2 inch through 2 inch, shall be rated for 35 PSI differential for water applications and 50 PSI differential for steam applications.

B. **Globe Valve Actuators**: See Actuator Specification for details.

2.06 SENSORS

A. **General**: Temperature sensors shall be of commercial grade quality and shall be installed according to the manufacturer's recommendations.

   1. Temperature sensors shall be adjusted from the operators work station.

B. **Temperature Sensors**:

   1. Temperature Sensors shall be of the wire-wound resistive element type (RTD). Duct air sensors shall use a bulb type element, except where averaging type elements shall be used for temperature indication. Averaging elements shall be used in mixed air applications.

C. **Flat Plate Temperature Sensor**: Stainless steel, flat plate, wall mount, thermistor space sensor shall be as manufactured by Pre-Con Corporation or approved equal.

   1. The active element shall be a highly stable, moisture/vapor resistant, precision Pre-Con thermistor, accurate to within plus or minus 0.36 degrees between 32 and 158 degrees F. The thermistor shall be bonded to a 403 stainless steel wall plate, with an insulated back, which shall reduce the conductive influence of the wall temperature.

      a. Thermistor shall be of Type III material and shall have a capacity of 10,000 ohm at 77 degrees F.

      b. Unit shall be furnished with 8 feet of 22 gauge zipcord and a recessed handibox (single gang box).

D. **Humidity Sensors**: Sensors shall be of commercial grade and shall have an accuracy of plus or minus 5 percent relative humidity.

E. **Pressure Sensors**: Pressure sensors shall have an accuracy of plus or minus 3 percent of full range.

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F. **Differential Pressures:** Differential pressures shall be function modules that are an integrated component of the system. Modules shall be available in multiple range appropriate for the application.

1. Accuracy shall be 1 percent of full range. This function module shall have an over/under pressure rating of 5 times full scale or 10 inches w.g., which ever is greater.

G. **Water Differential Pressure Sensor/Transmitter No. ST102:** Furnish and install two (2) complete, self-contained, strain gauge type differential pressure transmitters, Bell & Gossett ST102 or Rosemont 1151DP. Transmitters shall be located where indicated on Drawings. Wiring terminals and electronics shall be in separate compartments, so electronics remain sealed during installation. Reverse polarity protection shall be included to keep wiring mishaps from damaging transmitter.

1. The 4-20mA DC signal shall be transmitted over a pair of 18 gauge shielded cable (furnished and installed by this Contractor). Design range shall be as required by the system. External zero and span adjustments, over pressure to 2,000 psi, and no humidity effects.

2. Minimum accuracy shall be plus/minus .25 percent of calibrated span, including combined effects of linearity, hysteresis, and repeatability. Stability shall be plus/minus .25 percent of upper range limit for 6 months.

3. No internal mechanical linkages shall be used in the transmitters. Unit shall be protected against radio frequency interference and shall have a watertight (NEMA Type 4) electrical enclosure with 1/2 inch NPT conduit connection.

4. Variable speed pumping system manufacturer shall verify proper placement of differential pressure sensors and adjust or modify locations of these devices as required for proper operation of system at no additional cost to the Owner.

H. **CO_2 Sensors (Duct Mounted):** Veris Industries Model CDE, Tox-Alert or approved equal that is a non-dispersive infrared analyzer designed for measuring environmental CO_2 concentration in ventilation systems.

I. **CO_2 Sensors (Wall Mounted):** Veris Industries Model CWE, Tox-Alert or approved equal that is a non-dispersive infrared analyzer designed for measuring environmental CO_2 concentration in ventilation systems.

J. **Adjustable Setpoint Current Switch:** Hawkeye 938 Series.

2.07 AIR FLOW MEASURING STATIONS (AFMS)

A. **For Rooftop Units:**

1. General Requirements: Air flow stations shall be provided for all rooftop units. Stations shall be suitable for outside air temperatures and suitable for airflow down to 300 ft/min. AFMS shall be Air Monitor VOLU-flo/OAM outside air monitor, Tek-Air IAQ-Tek air monitor or approved equal.

2. AFMS shall consist of an inlet air flow sensor, an outside reference sensor and a monitor/controller module. The monitor/controller module shall be mounted on the unit.

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B. **For All Other Air Handling Units:**

1. General Requirements: Air flow stations shall be Ebtron Gold Series, Tek-Air, Air Monitor or approved equal for fan inlet and duct mounted type.

C. **Tolerance:** AFMS shall have an acceptable tolerance of +/-5% actual air flow over the operating range.

2.08 DAMPERS

A. **Characteristics:** Contractor shall provide control dampers of the types and sizes indicated on Drawings. Dampers shall be standard, parallel or opposed blade. Damper controls and necessary wiring shall be provided by Contractor.

1. When sized with an approach velocity of 1,500 fpm and damper is in the closed position against 2 inches of water static pressure, leakage shall not exceed 1-1/2 percent Standard series.

2. Damper frames shall be not less than 13 gauge galvanized formed steel. Blades shall be not less than 16 gauge galvanized steel, roll formed. Blades shall not exceed 8 inches in width and bearings shall be nylon or oilite with 1/2 inch zinc plated steel shafts.

a. Dampers located in aluminum ductwork (see Section 23 31 13) shall be constructed of aluminum material for the shaft, frame and blades.

3. Spring loaded stainless steel side seals shall be part of the frame to prevent leakage in the closed position.

4. Provide closed cell neoprene edging on the standard dampers.

PART 3 - EXECUTION

3.01 INSTALLATION

A. **General:** Actuators shall be sized and applied to minimize mechanical wear and twist on air control damper blades and operating shafts in accordance with actuator manufacturers recommendations.

B. **Mounting:** Actuators shall provide uniform torque to the air control damper drive shaft(s).

1. Control dampers having more than three horizontally connected sections and incorporating internal frame coupling(s) shall have actuators mounted on each end of the combined damper sections.

2. Actuators mounted on separate operating shafts of an air control damper shall have an actuator repeatability of no less than plus or minus one-half percent over the complete angle of rotation.

3. A weather shield shall be used if located outside. Ambient temperature rating of 122 degrees F shall not be exceeded through any combination of medium temperature or surrounding air. Appropriate air gaps, thermal isolation washers or spacers, standoff legs, or insulation shall be provided as necessary.

4. Water shall not be allowed to contact actuator or internal parts. Condensation in actuator shall be avoided by appropriate shielding or relocation outside high humidity air streams. Location of conduits in temperatures dropping below dew point shall be avoided to prevent water from condensing in conduit and running into actuator. Cords shall have a drip leg if condensation is possible.

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