

ADDENDUM NO. 1

February 24, 2026

**Carmel Middle School Mid-Life Cycle Renovation
300 S. Guilford Road
Carmel, IN 46032**

TO: ALL BIDDERS OF RECORD

This Addendum forms a part of and modifies the Bidding Requirements, Contract Forms, Contract Conditions, the Specifications and the Drawings dated January 23, 2026, by Fanning/Howe Associates. Acknowledge receipt of the Addendum in the space provided on the Bid Form. Failure to do so may subject the Bidder to disqualification.

This Addendum consists of Pages ADD 1-1 through ADD 1-2, Specification Section 00 20 00b IR Roof Scan, Guideline Schedule, and Fanning Howey Addendum No. 1, dated February 20, 2026, consisting of 9 items, 3 pages Revised Project Manual Sections: 23 05 00 – Common Work Results, 23 05 29 – Hangers, & Supports for HVAC Piping and Equipment, 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment, 23 05 93 – Testing, Adjusting, and Balancing for HVAC, 23 09 93 – HVAC Sequence of Operation, 23 21 13 – Hydronic Piping, 23 25 00 – HVAC Water Treatment, 23 31 13 – Metal Ducts, 23 33 00 – Air Duct Accessories, 23 37 13 – Diffusers, Registers, & Grilles, and 23 81 23 – Computer-Room Air-Conditioners Revised Drawing Sheets: A-501, AR101, MR101, MV101, MC109, M-501, M-601, and M-602.

A. SPECIFICATION SECTION 00 02 00 – INFORMATION AVAILABLE TO BIDDERS

- 1 . Insert IR Roof Scan for reference provided by Envelope Allies.

B. SPECIFICATION SECTION 01 12 00 MULTIPLE CONTRACT SUMMARY

A. Bid Category No 1 General Trades

Add the following Clarifications:

5. Responsible for removal and reinstall of interior glass panel to remove integral blinds as described in Note 1 on the Architectural Plans. This includes removal of the blinds.
6. Demo of asphalt path by Tennis is this Contractors responsibility.
7. Demo of asphalt parking lot where paving occurs is by Bid Category No. 6 Paving Contractor.

E. Bid Category No. 5 – Mechanical/Plumbing/Electrical

Add the following Clarifications:

4. Include 3 Test and Balance mobilization with 2 draft reports and a final at the end of the project.
5. All Fire Alarm devices are new with a complete new system. Include demo and removal of all existing fire alarm devices.

F. Bid Category No. 6 - Paving

Add the following Clarifications:

3. Responsible for asphalt demo where new paving occurs. Bid Category No. 1 - General Trades is responsible for asphalt path demo by Tennis Courts.

C. SPECIFICATION SECTION 01 32 00 SCHEDULES AND REPORTS

1. Insert included Guideline Schedule.

INFRARED ROOF INSPECTION REPORT
Carmel Middle School
300 S. Guilford Road
Carmel, IN 46032

September 12, 2025

Report Prepared by:



BUILDING ENVELOPE

ALLIES

CARMEL MIDDLE SCHOOL
300 S. GUILFORD ROAD
Carmel, IN 46032

Infrared Roof Inspection Report



Report Prepared for:
The Skillman Corporation
3834 S. Emerson Avenue #A
Indianapolis, IN 46203

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Introduction to the Infrared Flat Roof Moisture Survey

Infrared thermography is a form of non-contact, non-destructive testing used to detect and document thermal patterns and associated temperature differentials on the surface of a roof. For commercial roofing systems, infrared inspections can identify and document latent moisture. TSI Infrared Inspections are performed by Certified Thermographers using a portable infrared imaging system produced by FLIR Systems, Inc. This equipment detects infrared energy emitted from an object and converts it into an image which can be displayed on a screen and digitally saved to a storage device. TSI's FLIR imaging equipment has the capability to detect and record object temperatures ranging from -40°F to 3,632°F (-40°C to 2000°C), with a sensitivity of >0.07°F (<0.04°C).

On a sunny day, solar energy is absorbed by the roof surface and is transferred to the insulation layers of the roof. While dry insulation resists heat, wet insulation readily absorbs it. Since wet insulation has a greater thermal capacity, those areas of the roof which contain wet insulation cool off much slower than those areas of the roof which contain dry insulation, providing a temperature differential detectable by infrared imaging during the evening hours after the roof has begun to cool. Both debris and standing water interfere with roof thermography.

Temperature differentials can be used to create visual images on a digital monitor because infrared energy is a direct and proportional function of temperature. This *thermal* image looks very similar to a black and white television picture. The various shades of gray represent different temperature Areas throughout the chosen temperature range. Black corresponds to a lower temperature, and white indicates a higher temperature. In the color mode, colors are matched to the reference temperature bar at the side of the *thermogram*. Colors which appear closer to the top of the reference bar correspond to higher temperatures. Colors appearing closer to the bottom of the reference bar correspond to lower temperatures.

There is a non-destructive method recommended to utilize for confirmation of moisture present in areas located with infrared. An accepted method is by a moisture measurement device known as *electrical capacitance or Tramex*. The electrical capacitance meter generates two low frequency electronic signals that are transmitted through parallel electrodes located on the bottom side of the meter. The meter will indicate moisture present in the subsurface of the roofing material.

After an area of the roof with an elevated temperature is located by infrared imaging, the perimeter of the damaged area is then outlined with spray paint on the roof surface. Once the size and location of problem areas have been noted, a thermal image is taken of the designated areas. These *thermograms* and the identification of their physical locations provide building owners and managers with the necessary information to correct moisture intrusion problems.

Summary of Inspection and Findings

On September 12, 2025, an infrared roof moisture inspection was performed at 300 South Guilford Street in Carmel, Indiana. Nine (9) sections of the roof were inspected. At the time of the inspection no cores were cut.

The Inspection was observed by a Area II Certified Infrared Thermographer using a FLIR imaging system.

WEATHER CONDITIONS: On September 12, 2025, daytime skies were sunny with a high of 84 degrees. Evening skies were clear with low temperatures in the lower 60's.

FINDINGS:

The roof inspected consists of twenty-two (22) sections of approximately 242,000 SF of single-ply roofing system.

There were thirty-three (33) thermal anomalies identified that would indicate possible moisture within the makeup of the roof system. The areas were ~1,833 square feet or .0076% of the surveyed roof sections.

***Note:** The areas marked on drawings are not totally saturated from edge to edge (see images). Some locations have dry and wet areas that have been combined to simplify the process of marking, drawing and replacement if deemed necessary.*

RECOMMENDATIONS:

No information regarding the structural integrity of the building, the roof deck or the roof membrane is provided or implied in this report.

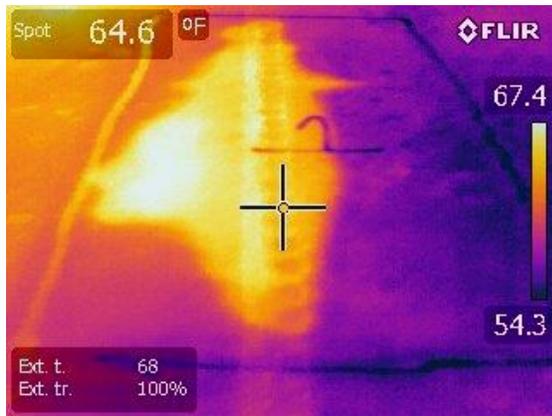
Many factors, such as sunlight, precipitation, wind, foot traffic and building movement, can affect the roof over a short period of time. Periodic infrared roof moisture Inspections will detect beginning problems and can assist in extending the life of the roofing system.

It is also recommended an infrared moisture survey be performed following the roofing project and every couple of years after to assure no more areas of moisture have developed to extend the life of the overall roof assembly.

If you should have any questions or if we can be of further assistance, please feel free to call.

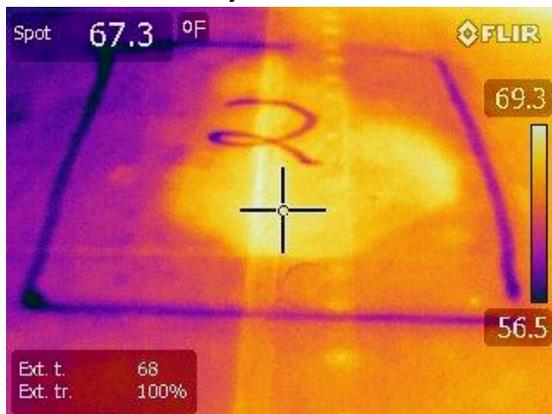
Russ Mink
Area II
Certified Infrared Thermographer

Thermal Image 1: Roof Area 7



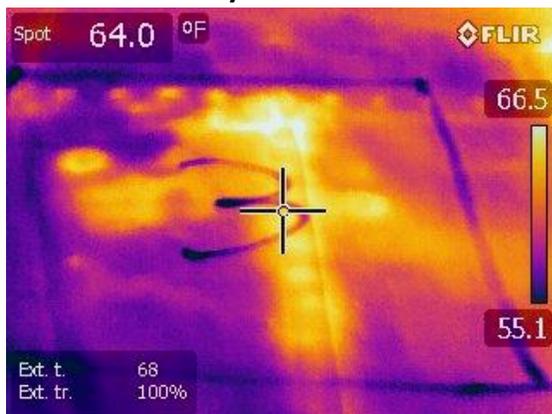
Area #1 is ~4'x12' = 48 sf.

Thermal Anomaly 2: Roof Area 7



Area #1 is ~4'x5' = 20 sf.

Thermal Anomaly 3: Roof Area 9



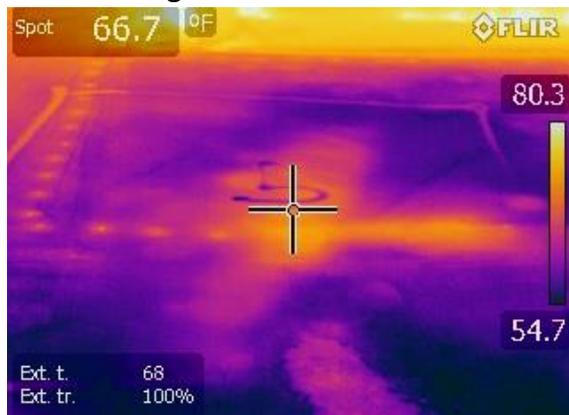
Area #3 is ~4'x5' = 20 sf.

Thermal Anomaly 4: Roof Area 9



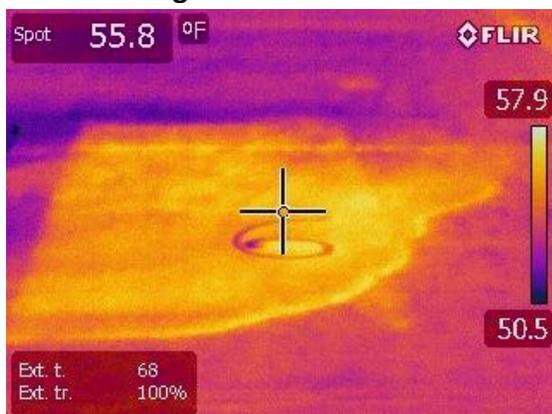
Area #4 is ~2'x27' = 54 sf.

Thermal Image 5: Roof Area 9



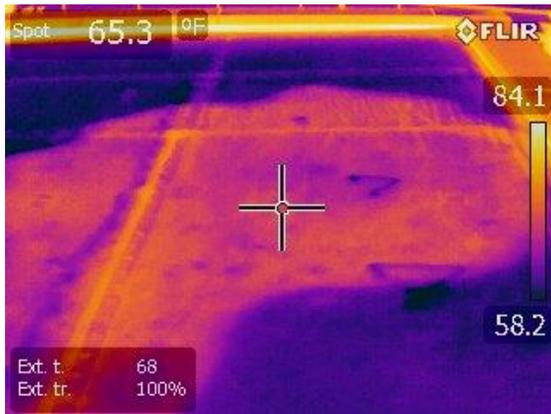
Area #5 is ~5'x7' = 35 sf.

Thermal Image 6: Roof Area 9



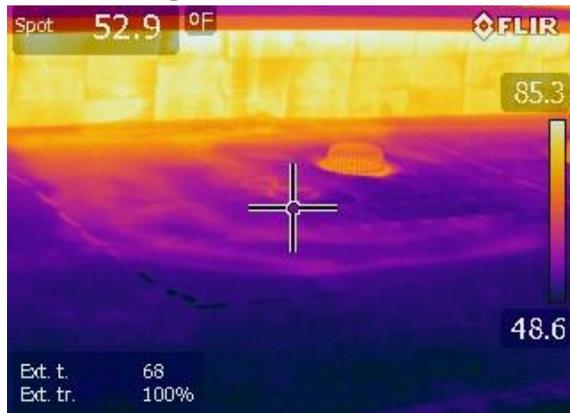
Area #6 is ~7'x10' = 70 sf.

Thermal Image 7: Roof Area 11



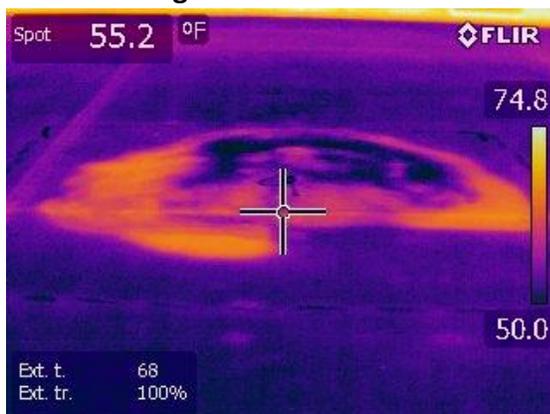
Area #7 is $\sim 7' \times 19' = 133$ sf.

Thermal Image 8: Roof Area 8



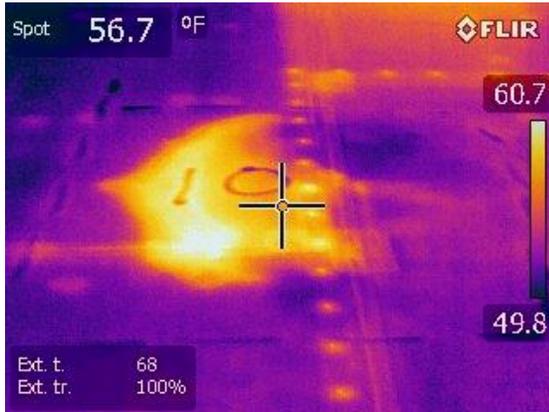
Area #8 is $\sim 9' \times 8' = 72$ sf.

Thermal Image 9: Roof Area 15



Area #9 is $\sim 11' \times 9' = 99$ sf.

Thermal Image 10: Roof Area 17



Area #10 is ~5'x4' = 20 sf.

Thermal Image 11: Roof Area 17



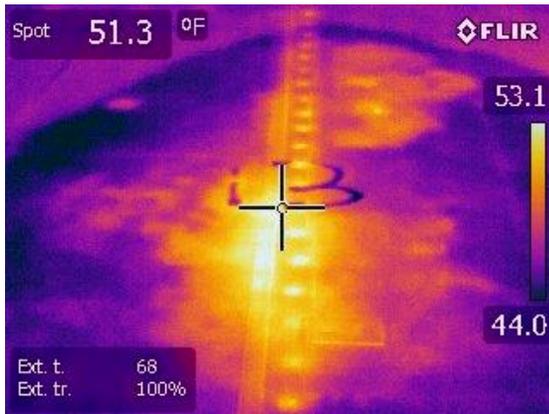
Area #11 is ~5'x3' = 15 sf.

Thermal Image 12: Roof Area 9



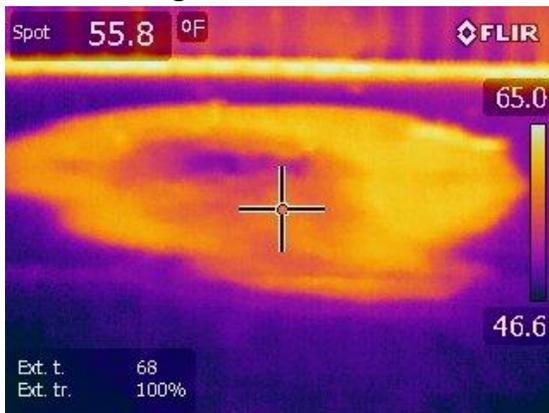
Area #12 is ~3'x2' = 6 sf.

Thermal Image 13: Roof Area 14



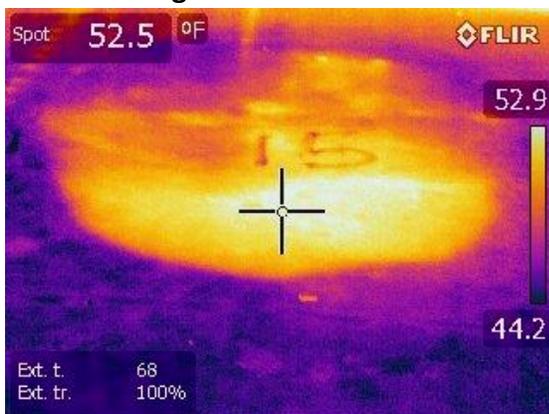
Area #13 is ~10'x5' = 50 sf.

Thermal Image 14: Roof Area 14



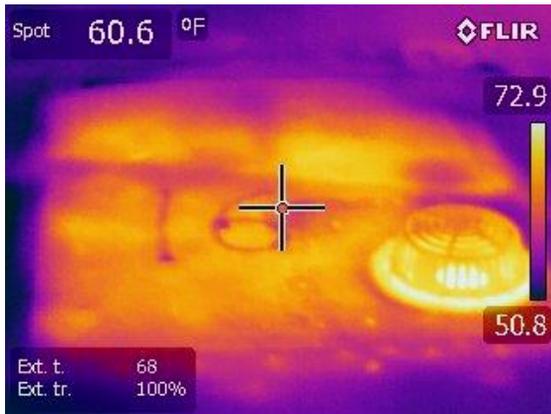
Area #14 is ~14'x9' = 126 sf.

Thermal Image 15: Roof Area 14



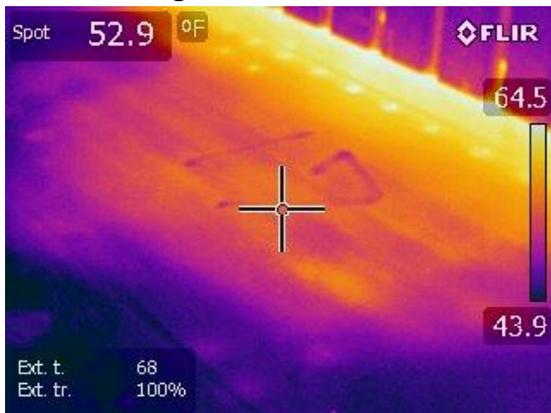
Area #15 is ~9'x6' = 54 sf.

Thermal Image 16: Roof Area 14



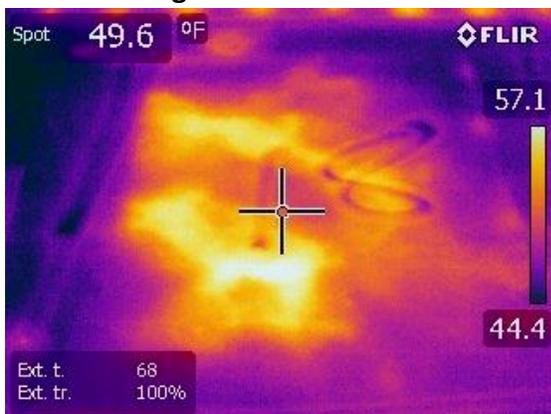
Area #16 is ~7'x5' = 35 sf.

Thermal Image 17: Roof Area 14



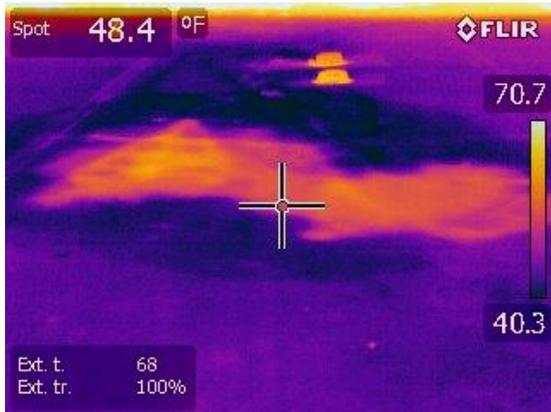
Area #17 is ~7'x4' = 28 sf.

Thermal Image 18: Roof Area 14



Area #18 is ~4'x3' = 12 sf.

Thermal Image 19: Roof Area 21



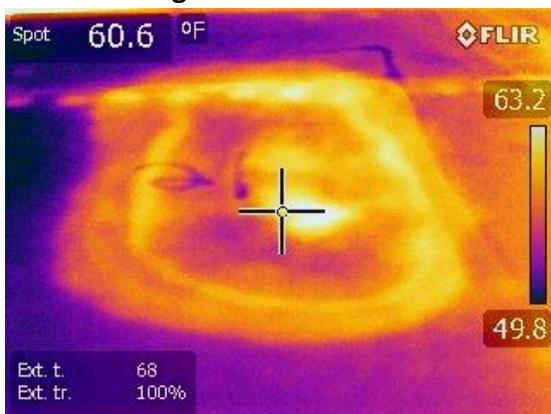
Area #19 is ~14'x11' = 154 sf.

Thermal Image 20: Roof Area 21



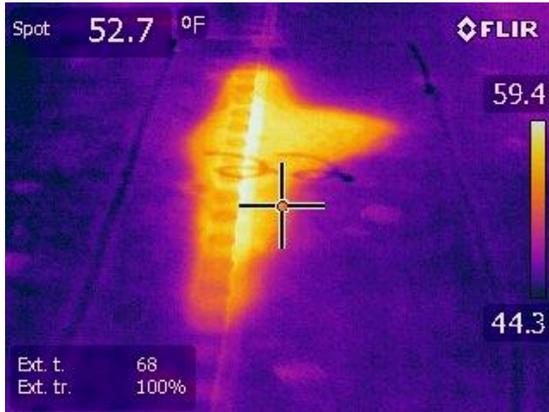
Area #20 is ~9'x9' = 81 sf.

Thermal Image 21: Roof Area 20



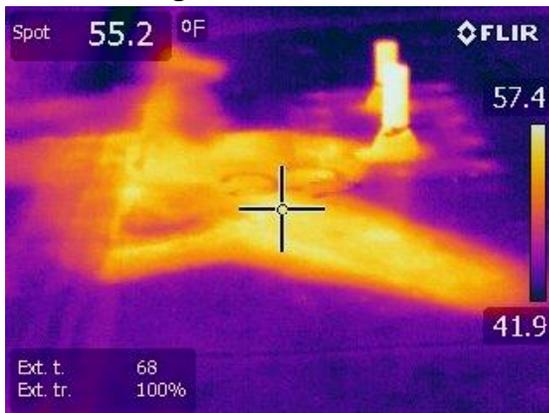
Area #21 is ~7'x5' = 35 sf.

Thermal Image 22: Roof Area 21



Area #22 is $\sim 10' \times 3' = 30$ sf.

Thermal Image 23: Roof Area 21



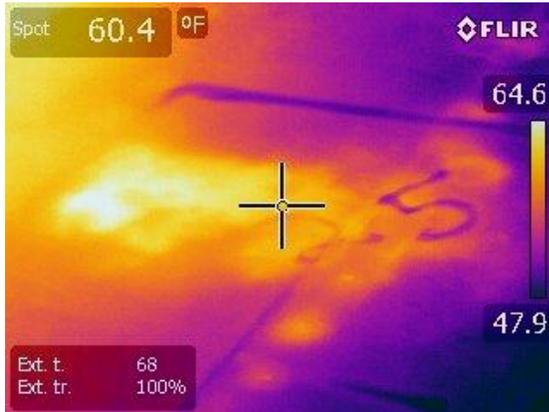
Area #23 is $\sim 13' \times 8' = 104$ sf.

Thermal Image 24: Roof Area 21



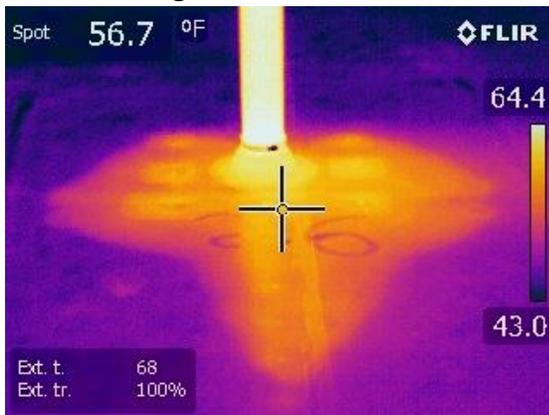
Area #24 is $\sim 13' \times 10' = 130$ sf.

Thermal Image 25: Roof Area 21



Area #25 is ~3'x3' = 9 sf.

Thermal Image 26: Roof Area 22



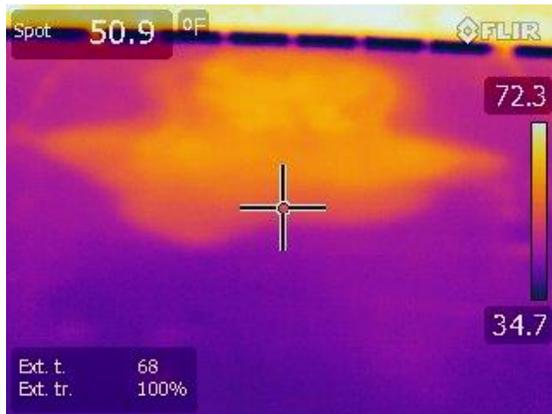
Area #26 is ~7'x5' = 35 sf.

Thermal Image 27: Roof Area 14



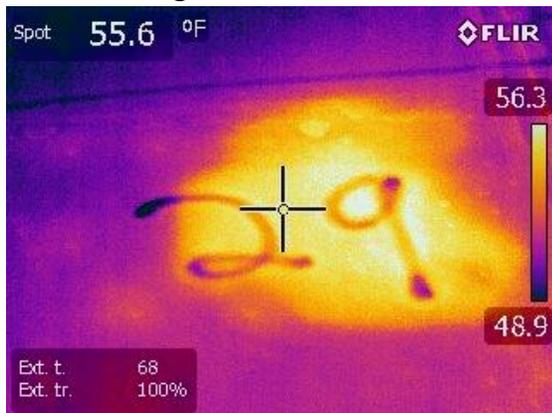
Area #27 is ~13'x6' = 78 sf.

Thermal Image 28: Roof Area 14



Area #28 is ~9'x7' = 63 sf.

Thermal Image 29: Roof Area 14



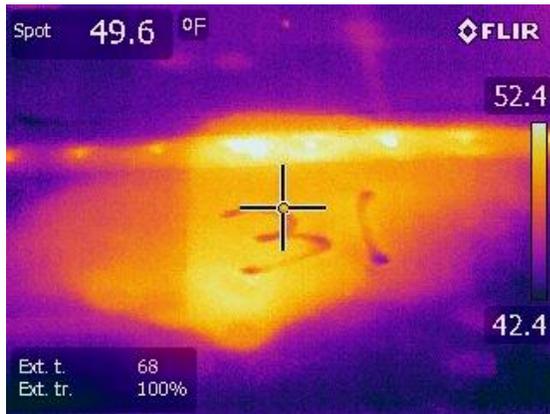
Area #29 is 4'x3' = 12 sf.

Thermal Image 30: Roof Area 14



Area #30 is ~10'x6' = 60 sf.

Thermal Image 31: Roof Area 14



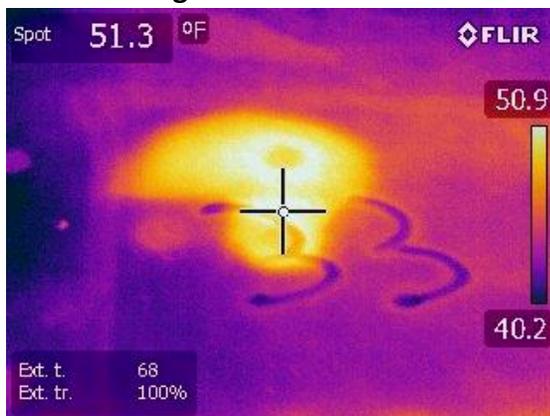
Area #31 is ~5'x4' = 20 sf.

Thermal Image 32: Roof Area 14



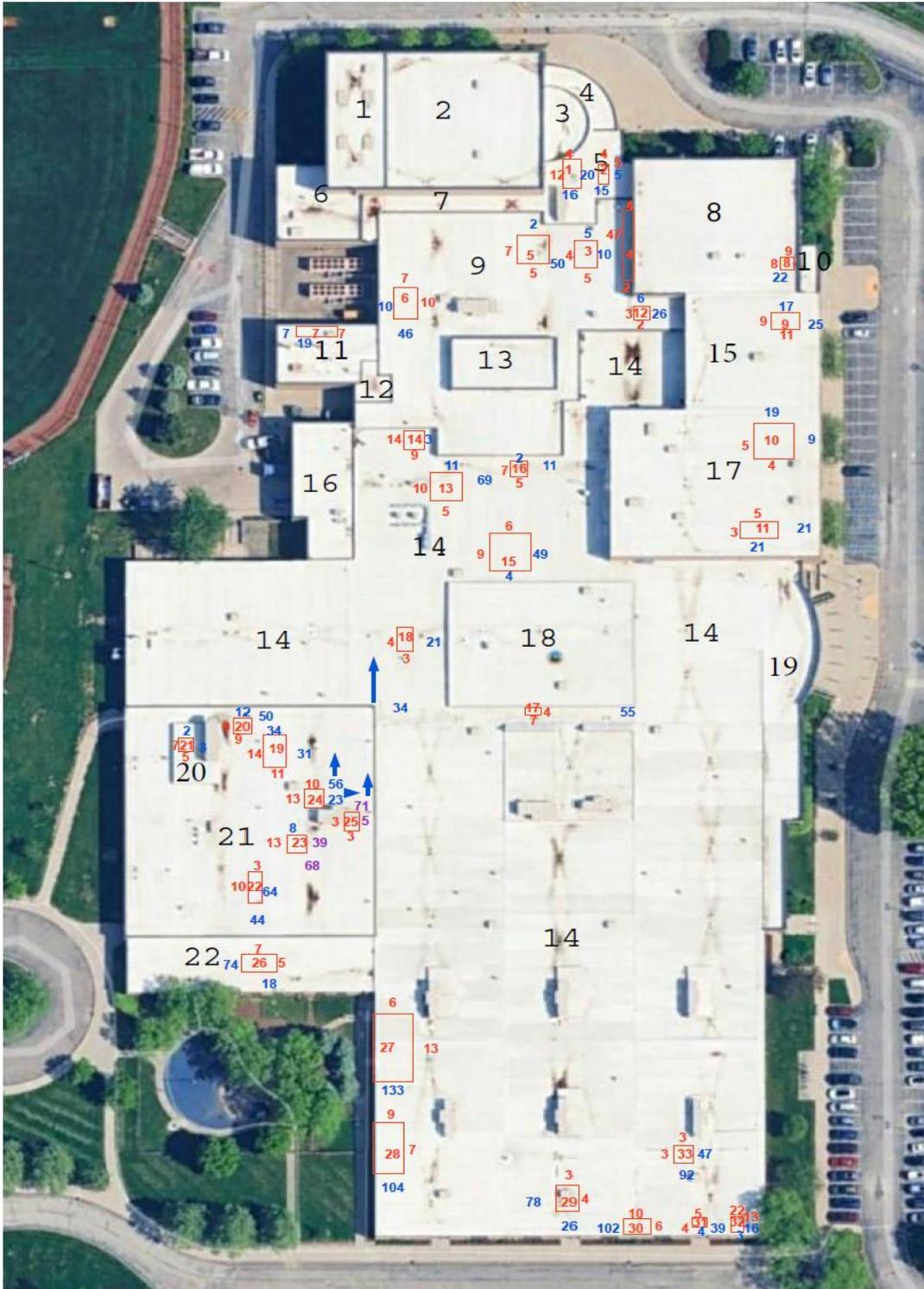
Area #32 is ~22'x13' = 286 sf.

Thermal Image 33: Roof Area 14



Area #33 is ~3'x3' = 9 sf.

Anomaly Map





BUILDING ENVELOPE
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Learn more about our services at:
www.evelopeallies.com
or call 1-317-581-2200

Activity Name	Original Duration	Start	Finish	2026												2027												2028			
				Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr		
Carmel MS Mid Life Reno	387	05-Mar-26	30-Aug-27	▶ 30-Aug-27, Carmel MS Mid Life Reno																											
Project Administration	387	05-Mar-26	30-Aug-27	▶ 30-Aug-27, Project Administration																											
Receive Bids	0	05-Mar-26*	05-Mar-26*	◆ Receive Bids																											
Board Approval	0	25-Mar-26*	25-Mar-26*	◆ Board Approval																											
Notice to Proceed Issued	0	27-Mar-26*	27-Mar-26*	◆ Notice to Proceed Issued																											
120 Days for Submittals	120	27-Mar-26*	10-Sep-26	▶ 120 Days for Submittals																											
Summer Break 2026 Start	0	26-May-26*	26-May-26*	◆ Summer Break 2026 Start																											
Phase 1 Interior Reno Substantial Completion	0	06-Aug-26	06-Aug-26	◆ Phase 1 Interior Reno Substantial Completion																											
Phase 2 Interior Reno Substantial Completion	0	12-Aug-26	12-Aug-26	◆ Phase 2 Interior Reno Substantial Completion																											
Phase 1 and 2 Interior Reno Punch List	15	13-Aug-26	02-Sep-26	▶ Phase 1 and 2 Interior Reno Punch List																											
Site Punch List	15	17-Aug-26	04-Sep-26	▶ Site Punch List																											
Phase 3 Interior Reno Substantial Completion	0	23-Sep-26	23-Sep-26	◆ Phase 3 Interior Reno Substantial Completion																											
Phase 3 Interior Reno Punch List	15	24-Sep-26	14-Oct-26	▶ Phase 3 Interior Reno Punch List																											
Site/Building Envelope Substantial Completion	0	28-Sep-26	28-Sep-26	◆ Site/Building Envelope Substantial Completion																											
Roofing Punch List	15	29-Sep-26	19-Oct-26	▶ Roofing Punch List																											
Central Plant Substantial Completion	0	26-Mar-27	26-Mar-27	◆ Central Plant Substantial Completion																											
Central Plant Punch List	15	29-Mar-27	16-Apr-27	▶ Central Plant Punch List																											
Phase 4 Interior Reno Substantial Completion	0	09-Aug-27	09-Aug-27	◆ Phase 4 Interior Reno Substantial Completion																											
Phase 4 Interior Renovation Punch List	15	10-Aug-27	30-Aug-27	▶ Phase 4 Interior Renovation Punch List																											
Project Complete	0	30-Aug-27	30-Aug-27	◆ Project Complete																											
Sitework/Building Envelope	90	26-May-26	28-Sep-26	▶ 28-Sep-26, Sitework/Building Envelope																											
Roofing	90	26-May-26*	28-Sep-26	▶ Roofing																											
Building Control Joint/Window Caulk Remediation	40	26-May-26	20-Jul-26	▶ Building Control Joint/Window Caulk Remediation																											
Tennis Court Sidewalk	20	26-May-26	22-Jun-26	▶ Tennis Court Sidewalk																											
Through Wall Flashing on Roof	10	26-May-26	08-Jun-26	▶ Through Wall Flashing on Roof																											
Brick/Flashing Window Remediation	45	09-Jun-26	10-Aug-26	▶ Brick/Flashing Window Remediation																											
North Sidewalk Demo at South Lot	7	23-Jun-26	01-Jul-26	▶ North Sidewalk Demo at South Lot																											
North Sidewalk and Curb at South Lot	20	02-Jul-26	29-Jul-26	▶ North Sidewalk and Curb at South Lot																											
Paving	5	30-Jul-26	05-Aug-26	▶ Paving																											
Striping	2	06-Aug-26	07-Aug-26	▶ Striping																											
Skillman Pre-Punch	5	10-Aug-26	14-Aug-26	▶ Skillman Pre-Punch																											
Interior Renovation	331	04-May-26	09-Aug-27	▶ 09-Aug-27, Interior Renovation																											
Phase 1 Gym/Media Center/Educare	69	04-May-26	06-Aug-26	▶ 06-Aug-26, Phase 1 Gym/Media Center/Educare																											
Fire Alarm Replacement	20	01-Jun-26*	26-Jun-26	▶ Fire Alarm Replacement																											
Replace Liebert Unit ACCU-1	10	20-Jul-26*	31-Jul-26	▶ Replace Liebert Unit ACCU-1																											
Gym (703A)	47	04-May-26	07-Jul-26	▶ 07-Jul-26, Gym (703A)																											
Paint Gym (703A)	10	04-May-26*	15-May-26	▶ Paint Gym (703A)																											
Replace Gym Wall Padding	5	18-May-26	22-May-26	▶ Replace Gym Wall Padding																											
Demo Gym (703A) Office/Lockers Support Spaces	5	25-May-26	29-May-26	▶ Demo Gym (703A) Office/Lockers Support Spaces																											
Paint	10	01-Jun-26	12-Jun-26	▶ Paint																											
Tile Restoration	5	15-Jun-26	19-Jun-26	▶ Tile Restoration																											
Flooring	5	22-Jun-26	26-Jun-26	▶ Flooring																											
Sports Flooring	10	22-Jun-26	03-Jul-26	▶ Sports Flooring																											
Shower Curtains	2	29-Jun-26	30-Jun-26	▶ Shower Curtains																											
Skillman Pre-Punch	5	01-Jul-26	07-Jul-26	▶ Skillman Pre-Punch																											

- ▶ Actual Work
- ▶ Remaining Work
- ▶ Critical Remaining Work
- ◆ Milestone
- ▶ Summary



Activity Name	Original Duration	Start	Finish	2026												2027												2028			
				Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr		
Phase 3 Gym (703B)	83	01-Jun-26	23-Sep-26																												
Demo Gym (703B) Office/Lockers Support Spaces	5	01-Jun-26	05-Jun-26																												
Paint	10	08-Jun-26	19-Jun-26																												
Tile Restoration	5	22-Jun-26	26-Jun-26																												
Flooring	5	29-Jun-26	03-Jul-26																												
Shower Curtains	2	06-Jul-26	07-Jul-26																												
Demo Sports Flooring	5	06-Aug-26	12-Aug-26																												
Paint Gym (703B)	10	13-Aug-26*	26-Aug-26																												
Replace Gym Wal Padding	5	27-Aug-26	02-Sep-26																												
Sports Flooring	15	27-Aug-26	16-Sep-26																												
Skillman Pre-Punch	5	17-Sep-26	23-Sep-26																												
Phase 4 Admin/Corridors/Auditorium/Classrooms	55	25-May-27	09-Aug-27																												
Owner Move Out	5	25-May-27*	31-May-27																												
Abatement Contractor Flooring Demo	10	01-Jun-27	14-Jun-27																												
Stage Rigging	20	01-Jun-27	28-Jun-27																												
Fire Alarm Replacement	40	01-Jun-27	26-Jul-27																												
Test and Balance Entire Building	40	01-Jun-27*	26-Jul-27																												
GT Selective Demo	10	03-Jun-27	16-Jun-27																												
Paint	20	15-Jun-27	12-Jul-27																												
Locker Painting	20	22-Jun-27	19-Jul-27																												
Flooring	30	22-Jun-27	02-Aug-27																												
Skillman Pre-Punch	5	03-Aug-27	09-Aug-27																												
Central Plant	170	03-Aug-26	26-Mar-27																												
Boiler Replacement	20	03-Aug-26*	28-Aug-26																												
HW Pump Replacement	10	31-Aug-26	11-Sep-26																												
Electrical Connections	10	14-Sep-26	25-Sep-26																												
Temp Controls	10	28-Sep-26	09-Oct-26																												
Chillers	40	21-Dec-26*	12-Feb-27																												
CW Pump Replacement	5	15-Feb-27	19-Feb-27																												
Electrical Connections	10	22-Feb-27	05-Mar-27																												
Temp Controls	10	08-Mar-27	19-Mar-27																												
Test and Balance	5	22-Mar-27	26-Mar-27																												

- Actual Work
- Remaining Work
- Critical Remaining Work
- Milestone
- Summary



ADDENDUM NO. 1

Carmel Middle School (CAM) Mid-Life Cycle Renovation

Carmel Clay Schools
Carmel, Indiana

Project No. 222009.00

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Addendum No. 1, 9 items, 3 pages

Revised Project Manual Sections: 23 05 00 – Common Work Results, 23 05 29 – Hangers, & Supports for HVAC Piping and Equipment, 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment, 23 05 93 – Testing, Adjusting, and Balancing for HVAC, 23 09 93 – HVAC Sequence of Operation, 23 21 13 – Hydronic Piping, 23 25 00 – HVAC Water Treatment, 23 31 13 – Metal Ducts, 23 33 00 – Air Duct Accessories, 23 37 13 – Diffusers, Registers, & Grilles, and 23 81 23 – Computer-Room Air-Conditioners
Revised Drawing Sheets: A-501, AR101, MR101, MV101, MC109, M-501, M-601, and M-602

February 20, 2026

I hereby certify that this Addendum was prepared by me or under my direct supervision and that I am a duly registered Architect/Engineer under the Laws of the State of Indiana.

FANNING/HOWEY ASSOCIATES, INC.
ARCHITECTS/ENGINEERS/CONSULTANTS



Paul A. Miller, License No. AR10800161
Expiration Date: 12/31/2027

TO: ALL BIDDERS OF RECORD

ADDENDUM NO. 1 to Drawings and Project Manual, dated January 23, 2026, for the Carmel Middle School (CAM) Mid-Life Cycle Renovation for Carmel Clay Schools, 5201 E. Main St., Carmel, Indiana 46033; as prepared by Fanning/Howey Associates, Inc., Indianapolis, Indiana.
This Addendum shall hereby be and become a part of the Contract Documents the same as if originally bound thereto.

The following clarifications, amendments, additions, revisions, changes, and modifications change the original Contract Documents only in the amount and to the extent hereinafter specified in this Addendum.

Each bidder shall acknowledge receipt of this Addendum in his proposal or bid.

NOTE: Bidders are responsible for becoming familiar with every item of this Addendum. (This includes miscellaneous items at the very end of this Addendum.)

RE: ALL BIDDERS

ITEM NO. 1. PROJECT MANUAL, TABLE OF CONTENTS

- A. Book 3, Page 00 01 10-1, DIVISION 23: Change title of Section 23 21 13 to "Hydronic Piping".

ITEM NO. 2. REVISED PROJECT MANUAL SECTIONS

- A. Sections 23 05 00 – Common Work Results, 23 05 29 – Hangers, & Supports for HVAC Piping and Equipment, 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment, 23 05 93 – Testing, Adjusting and Balancing for HVAC, 23 09 93 – HVAC Sequence of Operation, 23 21 13 – Hydronic Piping, 23 25 00 – HVAC Water Treatment, 23 31 13 – Metal Ducts, 23 33 00 – Air Duct Accessories, 23 37 13 – Diffusers, Registers, & Grilles, and 23 81 23 – Computer-Room Air-Conditioners have been revised, dated 02/20/26, and are included with and hereby made a part of this Addendum.

ITEM NO. 3. PROJECT MANUAL, SECTION 06 10 00 – ROUGH CARPENTRY

- A. Add 1.1, A., 3., as follows:

“3. Framing with dimension lumber, wood sleepers.”

- B. Add 2.3, A., 1., as follows:

“1. Framing for raised platforms/seating. Fire treat only in lieu of preservative-treatment.”

- C. Add Article 2.8 as follows:

“2.8 DIMENSION LUMBER FRAMING

- A. Joists, Rafters, Sleepers, and other Framing by Performance: Any species and grade with a modulus of elasticity of at least 1,500,000 psi and an extreme fiber stress in bending of at least 850 psi for 2-inch nominal thickness and 12-inch nominal width for single-member use.”

D. Add Article 3.4 as follows:

“3.4 FLOOR JOIST/SLEEPER INSTALLATION

- A. General: Install with crown edge up and support ends of each member with not less than 1-1/2 inches of bearing on wood or metal, or 3 inches on masonry.
- B. Provide solid blocking of 2-inch nominal thickness by depth of joist at ends of joists unless nailed to header or band.
- C. Lap members framing from opposite sides not less than 4 inches or securely tie opposing members together. Provide solid blocking of 2-inch nominal thickness by depth of joist over supports.
- D. Provide bridging of diagonal wood formed from 1-by-3 inch nominal size lumber at intervals of 96 inches o.c. between joists/sleepers.”

ITEM NO. 4. PROJECT MANUAL, SECTION 06 16 00 - SHEATHING

A. Add 1.1, A., 4., as follows:

“4. Subflooring.”

B. Add Article 2.9, as follows:

“2.9 SUBFLOORING AND UNDERLAYMENT

- A. Plywood Subflooring: Exposure 1, Structural 1 sheathing.
 - 1. Span Rating: Not less than 24 o.c. or 48/24.
 - 2. Nominal thickness: Not less than 3/4 inch.”

C. Add 2.2, B., 2., as follows:

“2. Subflooring:

- a. Glue and nail to wood framing.
- b. Space panels 1/8 inch apart at edges and ends.”

ITEM NO. 5. PROJECT MANUAL, SECTION 09 72 00 – WALL COVERINGS

A. Delete 1.1, A., 2., in its entirety.

B. Delete 1.1, A., 3., in its entirety.

C. Delete Article 2.3, in its entirety.

ITEM NO. 6. PROJECT MANUAL, SECTION 09 96 00 – HIGH-PERFORMANCE COATINGS

A. Add 3.10, A., 1., b., 1), as follows:

“1) Same as Topcoat.”

B. Add 3.10, B., 1., b., 1), as follows:

“1) Same as Topcoat.”

C. Add 3.10, C., 1., b., 1), as follows:

“1) Same as Topcoat.”

D. Add 3.10, D., 1., b., 1), as follows:

“1) Same as Topcoat.”

E. Add 3.10, E., 1., b., 1), as follows:

“1) Same as Topcoat.”

F. Add 3.10, F., 1., b., 1), as follows:

“1) Same as Topcoat.”

ITEM NO. 7. PROJECT MANUAL, SECTION 10 21 23 - CUBICLES

A. Replace 2.3, A., as follows:

“A. Manufacturers: Subject to compliance with requirements, provide products as indicated in the “List of Finishes”.

(Note: This revision deletes subparagraphs 1 – 11)

ITEM NO. 8. ACCEPTABLE MANUFACTURERS

The following manufacturers are to be considered acceptable manufacturers (suppliers and fabricators) for the Sections of the Specifications listed. Listed manufacturers are required to bid on products equal in type and design, size, function, and quality to that originally specified. Final decision as to equality of products specified versus those proposed shall be made by the Architect.

Section 11 61 33 – Rigging Systems
- I Weiss, Fairview, New Jersey

ITEM NO. 9. REVISED DRAWING SHEETS

A. Drawing Sheets: A-501, AR101, MR101, MV101, MC109, M-501, M-601, and M-602 have been revised, dated 2/20/26, and is included with and hereby made a part of this Addendum. These Drawings supersede the original documents.

END OF ADDENDUM

SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Escutcheons.
 - 3. Grout.
 - 4. HVAC demolition.
 - 5. Equipment installation requirements common to equipment sections.
 - 6. Painting and finishing.
 - 7. Concrete bases.
 - 8. Supports and anchorages.

1.2 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- F. The following are industry abbreviations for plastic materials:
 - 1. CPVC: Chlorinated polyvinyl chloride plastic.
 - 2. PE: Polyethylene plastic.
 - 3. PVC: Polyvinyl chloride plastic.
- G. The following are industry abbreviations for rubber materials:
 - 1. EPDM: Ethylene-propylene-diene monomer rubber.
 - 2. NBR: Acrylonitrile-butadiene rubber.

1.3 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Escutcheons.

1.4 INFORMATIONAL/QUALITY ASSURANCE/CONTROL SUBMITTALS

- A. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

- B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements. Mechanical Contractor is to assume all financial responsibility associated with higher electrical characteristics.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.
- C. Sheet metal accessories shall include air distribution outlets, air filters, sound attenuators and ductwork accessories.
- D. Store all insulation, ductwork, and sheet metal accessories indoors, or in a storage trailer. Do not store outdoors. Any insulation, ductwork, or accessories stored outdoors will be rejected, and shall be removed from the project site by the Contractor.
- E. Do not allow insulation, ductwork, or sheet metal accessories to be exposed to moisture, to avoid introduction of mold spores into the building.
- F. Do not run air systems prior to ductwork being insulated, to prevent condensation from occurring on the ductwork.
- G. Equipment covered under this article include the following:
 - 1. Air handling units
 - 2. Boilers
 - 3. Chillers
 - 4. Storage tanks
 - 5. VAV terminals
 - 6. Coils
 - 7. Unit heaters
 - 8. Cabinet unit heaters
 - 9. Exhaust fans
 - 10. Computer room air conditioners
 - 11. Combustion air units
 - 12. Duct mounted coils
 - 13. Pumps
 - 14. Heat pumps
 - 15. Energy recovery units
 - 16. Make-up air units
- H. Air handling units shall be shipped fully crated or shrink-wrapped from the factory for protection of the equipment from the weather.
- I. Equipment shall be stored at the site indoors, or outdoors on pallets where approved by A/E and CM. Do not set units directly on grade.
- J. Equipment shall be fully protected from moisture while being stored. Use heavy tarps with tie down straps or other means to protect the units from moisture and outdoor weather conditions.

- K. All air side devices such as air handling units, VAV terminals, coils, fans, terminal heating devices, ductwork and ductwork accessories shall be shipped, received and stored in such a manner that moisture is not allowed to be exposed to any portion of the equipment. Any equipment that is found to have or have had moisture present shall be removed from the job site and replaced.

1.7 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors in walls, ceilings, and floors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors for building components are specified in Division 08 Section "Access Doors and Frames." Access doors for ductwork are specified in Section 23 33 00 – Air Duct Accessories.
- D. Coordination Drawings: Contractors shall produce a coordinated set of installation drawings from Project Drawings to establish the final coordinated installation elevations and routing of building services, such as but not limited to duct, pipe, wiring, conduit, cabling, and etc.
 - 1. Coordination drawings shall be drawn to 1/4" = 1'0" scale.
 - 2. All building trades shall participate; Division 23 contractor shall lead coordination, review, and produce the finished document set for review.
 - 3. Generally, the following installation conditions shall be met to organize the different building materials, and as otherwise noted and identified on the Project Drawings.
 - a. Install Divisions 21, 22, 23, 25, 26 and 28 pipe and conduit mains first, at higher elevation(s); above duct mains and sub-mains.
 - b. Install Division 23 duct mains and sub-mains, typically higher is better, and not less than 12 inches above finished ceiling elevation.
 - c. Install branch duct, pipe and conduit run-outs, typically higher is better, and not less than 8 inches above the finished ceiling elevation.
 - d. Equipment is expected to be at an accessible and serviceable location, typically not more than 18 inches above the finished ceiling elevation.
 - e. Valves, dampers, and other manual controls shall be visible and accessible.
 - f. Access of components is considered from a ladder positioned below the ceiling elevation with the operator standing appropriately atop the ladder.
 - 4. Generalized routing of building utilities is not expected to vary significantly from Project Drawings, but coordination with the appropriate designer(s) shall be the responsibility of the contractor to facilitate if significant deviations are necessary.
 - 5. A fully coordinated and detailed set of installation drawings shall be submitted for review prior to commencement of installation; equipment procurement is expected to occur simultaneously with production of the coordinated installation document set.
 - 6. Coordinated document set shall account for all service and maintenance requirements of the intended/expected equipment selections.
 - 7. Failure to complete and submit coordination drawing(s) for review prior to installation of work will result in the rejection of the coordination drawing submission(s).
- E. Coordinate the use of pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.
- F. Contractor is responsible to coordinate requirements for access panels and doors and assign installation locations at walls, ceilings, and floors for HVAC items requiring access. Access doors for building components are specified in Division 08 Section "Access Doors and Frames." Access doors for ductwork are specified in Section 23 33 00.
- G. Coordinate with the Division 26 Contractor regarding the location of all Switchboards and Switchgear. Piping shall not be run over or near any Switchboard or Switchgear. Piping or ductwork foreign to the electrical installation whose malfunction would endanger the operation of the electrical system shall not be routed through the Main Electrical Room, shall not be routed

through the Main Emergency Equipment Room, and shall not be routed through the Emergency Generator Room. The exception would be statutorily required fire protection piping.

1. Piping should be avoided over any wall mounted electrical panel with a voltage of 120 volts or higher. Obtain written approval from Owners Representative before routing piping above an electrical panel.

1.8 PROJECT CONDITIONS

- A. Unless otherwise stipulated under a particular heading, the following rules relative to responsibilities of the several Contractors and subcontractors will apply.
 1. Each Contractor shall install roughing-in work pertaining to his trade for connection of Work performed under other Sections of these Specifications.
- B. Certain areas will be designated for the storage of materials and equipment and cooperation/coordination with the Owner in minimizing interferences with existing operations will be mandatory.
 1. Where possible, store materials inside and protected from weather. Where necessary to store outside, elevate above grade and enclose the durable, waterproof wrapping.
 2. Follow manufacturer's instructions for receiving, inspecting, handling, storage, and protection of products prior to final installation.
- C. Equipment Clearances and Requirements
 1. Due to the possibility of restrictions imposed by space limitations, the responsibility for resolving conflicts resulting from the use of equipment other than the design basis shall rest with the equipment supplier and the Contractor. Submittals for this equipment will be considered as a statement that clearances for access, service, maintenance, etc., have been checked and found adequate.
 2. Alternate equipment or the equipment of additional manufacturers named in these documents shall meet Base Bid specifications. In the event such equipment or any equipment which the bidder proposes to furnish, deviates from the requirements of equipment first named regarding electric service, power wiring, control wiring, plumbing or piping, sound attenuation, or vibration damping, it shall be the responsibility of the bidder to include in his price a sufficient sum to cover additional costs or charges resulting there from.
- D. In general, the piping and ductwork shown on the Drawings shall be considered as diagrammatic for clearness in indicating the general run and connections required, and may not be shown in its true position. The piping and ductwork and equipment may have to be offset, lowered or raised, as required, or as directed at the site in order to accommodate field conditions.

1.9 CLOSEOUT DOCUMENTS

- A. After corrections and any job installation changes, the contractor shall be responsible for delivering the following closeout documents to the owner. Each set of documents shall be provided in paper copy and digital format. The digital format shall be coordinated directly with the owner. Contractor responsible for any hard drive and/or storage requirements to deliver documents. Include items specified in Division 01 Section "Operation and Maintenance Data," along with the following:
 1. Full size as-built drawings (Quantity: 1)
 - a. Including ductwork, piping, temperature control schematics, etc.
 2. Complete parts list of HVAC equipment and accessories
 3. Specifications sheets
 4. Operation and maintenance manuals of all new HVAC equipment
 5. Refer to individual Division 23 sections for more specific requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Type: With set screw.
 - 1. Finish: Polished chrome-plated.
- D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated.
- E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.
- F. Split-Plate, Stamped-Steel Type: With concealed or exposed-rivet hinge, set screw or spring clips, and chrome-plated finish.
- G. One-Piece, Floor-Plate Type: Cast-iron floor plate.
- H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.4 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

- A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
 4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
 5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type with spring clips.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type and set screw.
 - h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with hinge and set screw.
 - j. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
 - k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.
 - l. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
 2. Existing Piping: Use the following:
 - a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
 - b. Insulated Piping: Split-plate, stamped-steel type with concealed or exposed-rivet hinge and spring clips.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
 - g. Bare Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated finish.
 - h. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed or exposed-rivet hinge and set screw or spring clips.
 - i. Bare Piping in Equipment Rooms: Split-casting, cast-brass type.
 - j. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.

k. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

B. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 DUCT SYSTEMS – COMMON REQUIREMENTS

A. Install ductwork according to the following requirements and Division 23 Sections specifying ductwork systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of ductwork systems. Indicated locations and arrangements were used to size ductwork and calculate friction loss, expansion, fan sizing, and other design considerations. Install ductwork in general location as indicated in Contract Documents unless deviations to layout are approved on Coordination Drawings. Minor offsets, lowering or raising the ductwork shall be routed to accommodate field conditions at no expense to the project.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

B. Install equipment level and plumb, parallel, and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

E. Coordinate ceiling mounted equipment locations to provide proper maintenance access and where possible, maintain a 24 by 24 inch clear path from the floor level to the equipment. All equipment above the ceiling shall be accessible via 10 foot (or shorter) ladder and shall be no more than 24 inches above the ceiling grid. Equipment mounted above ceilings that are greater than 10 feet high, shall have access via other means approved by the Owner, and as a minimum shall not require special lifts to access. The contractor shall coordinate with other trades to ensure that systems below the equipment (piping, cable trays, ductwork, etc.) shall not impede the service area or path to that service area. The contractor shall note service access areas on all shop drawings for ceiling mounted systems for all trades to ensure proper clearance.

3.5 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.
- B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.9 GROUTING

- A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

END OF SECTION 23 05 00

SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following hangers and supports for HVAC system piping and equipment:
 - 1. Steel pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Thermal-hanger shield inserts.
 - 5. Pipe stands.
 - 6. Equipment supports.
 - 7. Duct hangers and supports.
 - 8. Structural roof curbs.
 - 9. Pipe curbs.
- B. Related Sections include the following:
 - 1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
 - 2. Division 07 Section "Roof Accessories" for general information concerning roof accessories.
 - 3. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-protection piping.
 - 4. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
 - 5. Division 23 Section(s) "Metal Ducts" and "Nonmetal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Provide additional supplemental steel as required to support equipment, ductwork, piping, etc. from structure above.

1.5 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel pipe hangers and supports.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1, "Structural Welding Code--Steel."
 - 2. AWS D1.2, "Structural Welding Code--Aluminum."
 - 3. AWS D1.3, "Structural Welding Code--Sheet Steel."
 - 4. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
 - 5. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 STEEL PIPE HANGERS AND SUPPORTS

- A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.
- B. Manufacturers:
 - 1. AAA Technology & Specialties Co., Inc.
 - 2. Bergen-Power Pipe Supports.
 - 3. B-Line Systems, Inc.; a division of Cooper Industries.
 - 4. Carpenter & Paterson, Inc.
 - 5. Empire Industries, Inc.
 - 6. ERICO/Michigan Hanger Co.
 - 7. Globe Pipe Hanger Products, Inc.
 - 8. Grinnell Corp.
 - 9. GS Metals Corp.
 - 10. National Pipe Hanger Corporation.
 - 11. PHD Manufacturing, Inc.
 - 12. PHS Industries, Inc.
 - 13. Piping Technology & Products, Inc.
 - 14. Tolco Inc.
 - 15. Anvil International
- C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.
- E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

- A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

- B. Manufacturers:
 1. B-Line Systems, Inc.; a division of Cooper Industries.
 2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
 3. GS Metals Corp.
 4. Power-Strut Div.; Tyco International, Ltd.
 5. Thomas & Betts Corporation.
 6. Tolco Inc.
 7. Unistrut Corp.; Tyco International, Ltd.
- C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

- A. Description: 100-psig minimum, compressive-strength insulation insert encased in sheet metal shield.
- B. Manufacturers:
 1. Carpenter & Paterson, Inc.
 2. ERICO/Michigan Hanger Co.
 3. PHS Industries, Inc.
 4. Pipe Shields, Inc.
 5. Rilco Manufacturing Company, Inc.
 6. Value Engineered Products, Inc.
- C. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with vapor barrier.
- D. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass.
- E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 PIPE STAND FABRICATION

- A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
 1. Manufacturers:
 - a. ERICO/Michigan Hanger Co.
 - b. MIRO Industries.
- C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.
 1. Manufacturers:
 - a. MIRO Industries.
- D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 1. Manufacturers:
 - a. ERICO/Michigan Hanger Co.
 - b. MIRO Industries.
 - c. Portable Pipe Hangers.

2. Base: Plastic.
 3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
1. Manufacturers:
 - a. Portable Pipe Hangers.
 2. Bases: One or more plastic.
 3. Vertical Members: Two or more protective-coated-steel channels.
 4. Horizontal Member: Protective-coated-steel channel.
 5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.7 EQUIPMENT SUPPORTS

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

2.8 DUCT HANGERS AND SUPPORTS

- A. Support horizontal ductwork runs with suitable strap or trapeze hangers. When weight of duct between hangers does not exceed 60 pounds, hangers shall be 1 inch wide by 18 gauge. For greater weights, use trapeze hangers, as approved by A/E.
- B. Contractor may use load rated cable suspension system. Suspension system shall have a specified manufacturers safe working load and supplemental safety factor of at least five times the safe working load.
1. Suspension system shall be verified by SMACNA Testing and Research Institute to be in compliance with SMACNA Duct Construction Standards Guidelines (1995 CH.4).

2.9 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36, steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
1. Properties: Nonstaining, noncorrosive, and nongaseous.
 2. Design Mix: 5000-psi, 28-day compressive strength.

2.10 ROOF CURBS/EQUIPMENT SUPPORTS

- A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment".
- B. Equipment Supports: Internally reinforced metal equipment supports capable of supporting superimposed live and dead loads, including equipment loads and other construction indicated on Drawings; with welded or mechanically fastened and sealed corner joints, [**integral metal cant,**] [**stepped integral metal cant raised the thickness of roof insulation,**] and integrally formed deck-mounting flange at perimeter bottom.
- C. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - a. Materials: ASTM C1071, Type I or II.

- b. Thickness: 1-1/2 inches.
- 2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - a. Liner Adhesive: Comply with ASTM C916, Type I.
 - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
 - d. Liner Adhesive: Comply with ASTM C916, Type I.
 - e. Metal Counterflashing: Manufacturer's standard, removable, fabricated of same metal and finish as equipment support. Coordinate with roofing contractor.
 - f. On ribbed or fluted metal roofs, form deck-mounting flange at perimeter bottom to conform to roof profile.
 - g. Fabricate equipment supports to minimum height of 12 inches above finished roof surface, unless otherwise indicated.
 - h. Sloping Roofs: Where roof slope exceeds 1:48, fabricate each support with height to accommodate roof slope so that tops of supports are level with each other. Equip supports with water diverters or crickets on sides that obstruct water flow.

2.11 PIPE CURBS

- A. Pipe curb shall consist of a heavy gauge galvanized steel roof curb, unitized construction, with integral base plate, 3 pound density insulation, and 2 by 2 nailer. Curb shall be covered with a thermoplastic cover, fastening screws, graduated step boots with stainless steel adjustable clamps.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use padded hangers for piping that is subject to scratching.
- F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.

6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
 10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
 11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
 12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
 16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
 17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
 6. Swivel connections shall be utilized for attachment to sloping structure. Threaded rod shall not be bent.
- I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

- L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
- N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction. The use of powder-actuated fasteners or mechanical-expansion anchors may only be used after approval from the structural engineer.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.
- F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- H. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- K. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

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

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove welding flux immediately.
 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 23 05 29

SECTION 23 05 48 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 1. Isolation pads.
 2. Isolation mounts.
 3. Spring isolators.
 4. Elastomeric hangers.
 5. Spring hangers.
 6. Restrained vibration isolation roof-curb rails.
 7. Vibration isolation equipment bases.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

- A. Wind-Restraint Loading:
 1. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

1.5 ACTION SUBMITTALS

- A. Product Data: For the following:
 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
- B. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

1.6 INFORMATIONAL/QUALITY ASSURANCE/CONTROL SUBMITTALS

- A. Welding certificates.
- B. Field quality-control test reports.

1.7 CLOSEOUT DOCUMENTS

- A. General: Closeout Submittals are to be submitted with O and M Manuals only. Do not submit with other ACTION and INFORMATIONAL Submittals:
 1. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ace Mountings Co., Inc.
 - 2. Amber/Booth Company, Inc.
 - 3. California Dynamics Corporation.
 - 4. Isolation Technology, Inc.
 - 5. Kinetics Noise Control.
 - 6. Mason Industries.
 - 7. Vibration Eliminator Co., Inc.
 - 8. Vibration Isolation.
 - 9. Vibration Mountings & Controls, Inc.
 - 10. **<Insert manufacturer's name>**.
- B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - 1. Resilient Material: Oil- and water-resistant [**neoprene**] [**rubber**] [**hermetically sealed compressed fiberglass**].
- C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
 - 1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - 2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
- D. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
 - 1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
 - 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

- E. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
 - 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch-thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 - 2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
 - 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

- F. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.
 - 1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
 - 2. Base: Factory drilled for bolting to structure.
 - 3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel up or down before contacting a resilient collar.

- G. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

- H. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
 - 1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 - 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 - 7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

- I. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

- J. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Amber/Booth Company, Inc.
 - 2. California Dynamics Corporation.

3. Isolation Technology, Inc.
 4. Kinetics Noise Control.
 5. Mason Industries.
 6. Thybar Corporation.
 7. Vibration Eliminator Co., Inc.
 8. Vibration Isolation.
 9. Vibration Mountings & Controls, Inc.
- B. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment.
- C. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic[**and wind**] forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly.
- D. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch- thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.
1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators.
 - a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
 - b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 2. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - a. Resilient Material: Oil- and water-resistant.
- E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.
- F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

2.3 VIBRATION ISOLATION EQUIPMENT BASES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
 2. California Dynamics Corporation.
 3. Isolation Technology, Inc.
 4. Kinetics Noise Control.
 5. Mason Industries.
 6. Vibration Eliminator Co., Inc.
 7. Vibration Isolation.
 8. Vibration Mountings & Controls, Inc.
- B. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36. Bases shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- C. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
 4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.4 FACTORY FINISHES

- A. Finish: Manufacturer's standard prime-coat finish ready for field painting.
- B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
 1. Powder coating on springs and housings.
 2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
 3. Baked enamel or powder coat for metal components on isolators for interior use.
 4. Color-code or otherwise mark vibration isolation **[and seismic and wind]**-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation **[and seismic and wind]**-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps.
- B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL INSTALLATION

- A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- B. Equipment Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
- C. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 - 3. Brace a change of direction longer than 12 feet.
- D. Install cables so they do not bend across edges of adjacent equipment or building structure.
- E. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- F. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- G. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

3.4 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 01 Section "Demonstration And Training."

END OF SECTION 23 05 48

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes TAB to produce design objectives for the following:
 - 1. Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
 - c. Exhaust systems.
 - d. Energy recovery systems.
 - 2. Hydronic Piping Systems:
 - a. Constant-flow systems.
 - b. Variable-flow systems.
 - c. Primary-secondary systems.
 - 3. HVAC equipment quantitative-performance settings.
 - 4. Space pressurization testing and adjusting.
 - 5. Existing systems TAB.
 - 6. Verifying that automatic control devices are functioning properly.
 - 7. Reporting results of activities and procedures specified in this Section.

1.2 DEFINITIONS

- A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
- B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.
- C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.
- D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
- E. NC: Noise criteria.
- F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
- G. RC: Room criteria.
- H. Report Forms: Test data sheets for recording test data in logical order.
- I. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
- J. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
- K. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- L. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

- M. TAB: Testing, adjusting, and balancing.
- N. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- O. Test: A procedure to determine quantitative performance of systems or equipment.
- P. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.3 ACTION SUBMITTALS

- A. Product Data: Test and balance report shall be sent to the Engineer for review and approval upon completion of testing and balancing.

1.4 CLOSEOUT SUBMITTALS

- A. General: Closeout Submittals are to be submitted with O and M Manuals only. Do not submit with other ACTION and INFORMATIONAL Submittals:
 - 1. Operation and Maintenance Data: Include the Engineer reviewed and approved test and balance report in operation and maintenance manuals. This test and balance report shall bear the Engineers submittal stamp.

1.5 INFORMATIONAL/QUALITY ASSURANCE/CONTROL SUBMITTALS

- A. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- B. Warranties specified in this Section.

1.6 QUALITY ASSURANCE

- A. TAB Firm Qualifications: Engage a TAB firm certified by either AABC or NEBB.
- B. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.
- C. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems," NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing."
- D. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems, " Section II, " Required Instrumentation for NEBB Certification."
- E. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
 - 1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.
- F. Establish setpoints and calibrate controls. Coordinate with the Temperature Control Contractor and HVAC Contractor.

- G. Mark final control damper and volume damper positions.

1.7 PROJECT CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Coordinate/cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.8 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.
- C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.
- D. The Building Automation System shall be fully operational and adjustable before final balancing can be accomplished.

1.9 WARRANTY

- A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:
 - 1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
 - 2. Systems are balanced to optimum performance capabilities within design and installation limits.
- B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:
 - 1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
 - 2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
 - 1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
 - 2. Verify that balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are installed as required 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 01 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.
- 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 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. Examine automatic temperature system components to verify the following:
 1. Dampers, valves, and other controlled devices are operated by the intended controller.
 2. Dampers and valves are in the position indicated by the controller.
 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
 4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
 6. Sensors are located to sense only the intended conditions.
 7. Sequence of operation for control modes is according to the Contract Documents.
 8. Controller set points are set at indicated values.
 9. Interlocked systems are operating.
 10. Changeover from heating to cooling mode occurs according to indicated values.

- R. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes 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.
 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.
 9. Relief air system adjustment.

3.3 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 Heating, Ventilating, and Air Conditioning Systems", NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" 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.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "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.
- 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. Identify fan and motor RPM, motor current and voltage, fan coil, and filter status.
- I. Check dampers for proper position to achieve desired airflow path.
- J. Check for airflow blockages.
- K. Check condensate drains for proper connections and functioning.
- L. Check for proper sealing of air-handling unit components.
- M. Check for proper sealing of air duct system.

3.5 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.
 - 2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
 - a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
 - 3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, 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 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. Coordinate with Division 23 Contractor to provide correct sheave size to allow fan motor to produce full rated horsepower with the (VFC) variable frequency controller at 100 percent speed. The maximum design airflow shall be accommodated by reducing the fan speed through the VFC. Make required adjustments to pulley sizes, motor sizes, and electrical connections as required.
 - 8. Record air handling unit airflow during normal unit occupied and unoccupied operation and during economizer operation.
- B. Adjust volume dampers for main duct, submain 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 submain 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. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain 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.
- 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.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Adjust air handling unit 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.
 - 2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and treating equipment.
 - a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
 - 3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, 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. Provide correct sheave size to allow fan motor to produce full rated horsepower with the (VFC) variable frequency controller at 100 percent speed. The maximum design airflow shall be accommodated by reducing the fan speed through the VFC. Make required adjustments to pulley sizes, motor sizes, and electrical connections as required.
 - 6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers above 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. Record air handling unit airflow during normal unit occupied and unoccupied operation and during economizer operation.
- B. 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.
- C. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 - 1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
 - 2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
 - 3. Set terminal units at full-airflow condition.

4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.
7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

3.7 PROCEDURES FOR EXHAUST 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.
 2. Compare design data with installed conditions to determine variations in design static pressure 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.
 3. Obtain approval from A/E 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.
 4. 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.
 5. Coordinate with Division 23 Contractor to provide correct sheave size to allow fan motor to produce full rated horsepower with the (VFC) variable frequency controller at 100 percent speed. The maximum design airflow shall be accommodated by reducing the fan speed through the VFC. Make required adjustments to pulley sizes, motor sizes, and electrical connections as required.
 6. Record air handling unit airflow during normal unit occupied and unoccupied operation and during economizer operation.
- B. Adjust volume dampers for main duct, submain 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 submain 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. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Measure air devices without making adjustments.
 1. Measure air devices using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. Adjust air devices for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers.
 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.

3.8 PROCEDURES FOR ENERGY RECOVERY WHEELS

- A. Balance the supply and exhaust airstreams to minimum airflows. Measure the static pressure across the wheel for both supply and exhaust airstreams with the bypass dampers closed.

- B. Balance the supply and exhaust air streams to maximum airflows. Measure the static pressure across the wheel and bypass dampers for both supply and exhaust airstreams with the bypass dampers open.

3.9 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 gauge 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 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.
 9. Determine optimum pressure setting of differential pressure transmitter. Coordinate with the Temperature Control Contractor.
 10. All coils with 3-way temperature control valves have manual balance valves on the bypass leg. Adjust the pressure drop through the bypass leg to match the pressure drop through the coil at full flow.

3.10 PROCEDURES FOR HYDRONIC SYSTEMS

- A. 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. Convert pressure to head and correct for differences in gauge heights. 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.
- B. Set calibrated balancing valves, if installed, at calculated presettings.
- C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
 1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- E. 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.
 4. When automatic flow control valves are used, measure pressure drop across valve. Verify pressure drop is within valve operating range. Submit pressure and waterflow results in final report schedule.
- F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
- G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.
- 3.11 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS
- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.
 - B. Balance pump flow with all valves to the 100 percent open location.
 - C. Triple-duty valve shall be fully open.
 - D. Adjust pump flow by reducing (VFC) variable frequency-controller speed to attain scheduled flow rate.
- 3.12 PROCEDURES FOR PRIMARY-SECONDARY-FLOW HYDRONIC SYSTEMS
- A. Balance the primary system crossover flow first, then balance the secondary system.
 - B. Refer to procedures for variable flow hydronic systems.
- 3.13 PROCEDURES FOR MOTORS
- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 1. Manufacturer, model, and serial numbers.
 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.
 - 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.
- 3.14 PROCEDURES FOR CHILLERS
- A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the minimum and maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
 1. Evaporator-water entering and leaving temperatures, pressure drop, and minimum and maximum water flow.
 2. If air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.15 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record compressor data.

3.16 PROCEDURES FOR BOILERS

- A. If hydronic, measure entering- and leaving-water temperatures and water flow.
- B. Minimum and maximum water flow.
- C. Water pressure drop.
- D. If steam, measure entering-water temperature and flow and leaving steam pressure, temperature, and flow.

3.17 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Water Coils: Measure the following data for each coil:
 - 1. Entering- and leaving-water temperature.
 - 2. Water flow rate.
 - 3. Water pressure drop.
 - 4. Dry-bulb temperature of entering and leaving air.
 - 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 - 6. Airflow.
 - 7. Air pressure drop.
- B. Electric-Heating Coils: Measure the following data for each coil:
 - 1. Nameplate data.
 - 2. Airflow.
 - 3. Entering- and leaving-air temperature at full load.
 - 4. Voltage and amperage input of each phase at full load and at each incremental stage.
 - 5. Calculated kilowatt at full load.
 - 6. Fuse or circuit-breaker rating for overload protection.
- C. Refrigerant Coils: Measure the following data for each coil:
 - 1. Dry-bulb temperature of entering and leaving air.
 - 2. Wet-bulb temperature of entering and leaving air.
 - 3. Airflow.
 - 4. Air pressure drop.
 - 5. Refrigerant suction pressure and temperature.

3.18 PROCEDURES FOR TEMPERATURE MEASUREMENTS

- A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
- B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.
- C. Measure outside-air, wet- and dry-bulb temperatures.

3.19 PROCEDURES FOR SPACE PRESSURIZATION MEASUREMENTS AND ADJUSTMENTS

- A. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable safing, gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.
- B. Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.
- C. Measure space pressure differential where pressure is used as the design criteria, and measure airflow differential where differential airflow is used as the design criteria for space pressurization.
 - 1. For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.
 - 2. For applications with cascading levels of space pressurization, begin in the most critical space and work to the least critical space.
 - 3. Test room pressurization first, then zones, and finish with building pressurization.
- D. To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.
- E. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.
 - 1. Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
 - 2. Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test overpressurization and underpressurization, and observe and report on the system's ability to revert to the set point.
 - 3. For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.
- F. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.
- G. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.20 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

- A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
 - 1. Measure and record the operating speed, airflow, and static pressure of each fan.
 - 2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
 - 3. Check the refrigerant charge.
 - 4. Check the condition of filters.
 - 5. Check the condition of coils.
 - 6. Check the operation of the drain pan and condensate drain trap.
 - 7. Check bearings and other lubricated parts for proper lubrication.
 - 8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
- B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished.
 - 1. New filters are installed.
 - 2. Coils are clean and fins combed.
 - 3. Drain pans are clean.

4. Fans are clean.
 5. Bearings and other parts are properly lubricated.
 6. Deficiencies noted in the preconstruction report are corrected.
- C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
1. Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan, speed, filter, and coil face velocity.
 2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
 3. If calculations increase or decrease the airflow and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.
 4. Air balance each air outlet and inlet.

3.21 TEMPERATURE-CONTROL VERIFICATION

- A. Verify that controllers are calibrated and commissioned.
- B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- C. Record controller settings and note variances between set points and actual measurements.
- D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).
- E. Check free travel and proper operation of control devices such as damper and valve operators.
- F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.
- G. Check the interaction of electrically operated switch transducers.
- H. Check the interaction of interlock and lockout systems.
- I. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
- J. Note operation of electric actuators using spring return for proper fail-safe operations.

3.22 TOLERANCES

- A. Set HVAC system airflow and water flow rates within the following tolerances:
 1. Supply, Return, and Exhaust Fans and Equipment with Fans: 0 to plus 10 percent.
 2. Air Outlets and Inlets: 0 plus 10 percent.
 3. Heating-Water Flow Rate: 0 to plus 10 percent.
 4. Cooling-Water Flow Rate: 0 to plus 10 percent.

3.23 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

- B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.24 FINAL REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
 - 1. Include a list of instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to certified field report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.
- D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
 - 1. Title page.
 - 2. Name and address of TAB firm.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.
 - 6. Engineer's name and address.
 - 7. Contractor's name and address.
 - 8. Report date.
 - 9. Signature of TAB firm who certifies the report.
 - 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 - 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 - 12. Nomenclature sheets for each item of equipment.
 - 13. Data for terminal units, including manufacturer, type size, and fittings.
 - 14. Notes to explain why certain final data in the body of reports varies from indicated values.
 - 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outside-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
 - 1. Quantities of outside, supply, return, and exhaust airflows.
 - 2. Water and steam flow rates.
 - 3. Duct, outlet, and inlet sizes.
 - 4. Pipe and valve sizes and locations.
 - 5. Terminal units.

6. Balancing stations.
7. Position of balancing devices.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data: Include the following:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Sheave dimensions, center-to-center, and amount of adjustments in inches.
 - j. Number of belts, make, and size.
 - k. Number of filters, type, and size.
2. Motor Data:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Filter static-pressure differential in inches wg.
 - f. Preheat coil static-pressure differential in inches wg.
 - g. Cooling coil static-pressure differential in inches wg.
 - h. Heating coil static-pressure differential in inches wg.
 - i. Outside airflow in cfm.
 - j. Return airflow in cfm.
 - k. Outside-air damper position.
 - l. Return-air damper position.
 - m. Vortex damper position.

G. Apparatus-Coil Test Reports:

1. Coil Data:
 - a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Fin spacing in fins per inch o.c.
 - f. Make and model number.
 - g. Face area in sq. ft.
 - h. Tube size in NPS.
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Average face velocity in fpm.
 - c. Air pressure drop in inches wg.
 - d. Outside-air, wet- and dry-bulb temperatures in deg F.
 - e. Return-air, wet- and dry-bulb temperatures in deg F.
 - f. Entering-air, wet- and dry-bulb temperatures in deg F.
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F.
 - h. Water flow rate in gpm.
 - i. Water pressure differential in feet of head or psig.

- j. Entering-water temperature in deg F.
 - k. Leaving-water temperature in deg F.
 - l. Refrigerant expansion valve and refrigerant types.
 - m. Refrigerant suction pressure in psig.
 - n. Refrigerant suction temperature in deg F.
 - o. Inlet steam pressure in psig.
- H. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Fuel type in input data.
 - g. Output capacity in Btuh.
 - h. Ignition type.
 - i. Burner-control types.
 - j. Motor horsepower and rpm.
 - k. Motor volts, phase, and hertz.
 - l. Motor full-load amperage and service factor.
 - m. Sheave make, size in inches, and bore.
 - n. Sheave dimensions, center-to-center, and amount of adjustments in inches.
 2. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Entering-air temperature in deg F.
 - c. Leaving-air temperature in deg F.
 - d. Air temperature differential in deg F.
 - e. Entering-air static pressure in inches wg.
 - f. Leaving-air static pressure in inches wg.
 - g. Air static-pressure differential in inches wg.
 - h. Low-fire fuel input in Btuh.
 - i. High-fire fuel input in Btuh.
 - j. Manifold pressure in psig.
 - k. High-temperature-limit setting in deg F.
 - l. Operating set point in Btuh.
 - m. Motor voltage at each connection.
 - n. Motor amperage for each phase.
 - o. Heating value of fuel in Btuh.
- I. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Coil identification.
 - d. Capacity in Btuh.
 - e. Number of stages.
 - f. Connected volts, phase, and hertz.
 - g. Rated amperage.
 - h. Airflow rate in cfm.
 - i. Face area in sq. ft.
 - j. Minimum face velocity in fpm.
 2. Test Data (Indicated and Actual Values):
 - a. Heat output in Btuh.
 - b. Airflow rate in cfm.
 - c. Air velocity in fpm.
 - d. Entering-air temperature in deg F.
 - e. Leaving-air temperature in deg F.

- f. Voltage at each connection.
 - g. Amperage for each phase.
- J. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Sheave dimensions, center-to-center, and amount of adjustments in inches.
 2. Motor Data:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
 - g. Number of belts, make, and size.
 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
- K. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:
 - a. System and air-handling unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft.
 - g. Indicated airflow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual airflow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.
- L. Air-Terminal-Device Reports:
1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Test apparatus used.
 - d. Area served.
 - e. Air-terminal-device make.
 - f. Air-terminal-device number from system diagram.
 - g. Air-terminal-device type and model number.
 - h. Air-terminal-device size.
 - i. Air-terminal-device effective area in sq. ft.
 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.

- f. Final velocity in fpm.
 - g. Space temperature in deg F.
- M. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Entering-water temperature in deg F.
 - c. Leaving-water temperature in deg F.
 - d. Water pressure drop in feet of head or psig.
 - e. Entering-air temperature in deg F.
 - f. Leaving-air temperature in deg F.
- N. Packaged Chiller Reports:
1. Unit Data:
 - a. Unit identification.
 - b. Make and model number.
 - c. Manufacturer's serial number.
 - d. Refrigerant type and capacity in gal.
 - e. Starter type and size.
 - f. Starter thermal protection size.
 - g. Compressor make and model number.
 - h. Compressor manufacturer's serial number.
 2. Water-Cooled Condenser Test Data (Indicated and Actual Values):
 - a. Refrigerant pressure in psig.
 - b. Refrigerant temperature in deg F.
 - c. Entering-water temperature in deg F.
 - d. Leaving-water temperature in deg F.
 - e. Entering-water pressure in feet of head or psig.
 - f. Water pressure differential in feet of head or psig.
 3. Air-Cooled Condenser Test Data (Indicated and Actual Values):
 - a. Refrigerant pressure in psig.
 - b. Refrigerant temperature in deg F.
 - c. Entering- and leaving-air temperature in deg F.
 4. Evaporator Test Reports (Indicated and Actual Values):
 - a. Refrigerant pressure in psig.
 - b. Refrigerant temperature in deg F.
 - c. Entering-water temperature in deg F.
 - d. Leaving-water temperature in deg F.
 - e. Entering-water pressure in feet of head or psig.
 - f. Water pressure differential in feet of head or psig.
 5. Compressor Test Data (Indicated and Actual Values):
 - a. Suction pressure in psig.
 - b. Suction temperature in deg F.
 - c. Discharge pressure in psig.
 - d. Discharge temperature in deg F.
 - e. Oil pressure in psig.
 - f. Oil temperature in deg F.
 - g. Voltage at each connection.
 - h. Amperage for each phase.
 - i. Kilowatt input.
 - j. Crankcase heater kilowatt.
 - k. Chilled-water control set point in deg F.
 - l. Condenser-water control set point in deg F.
 - m. Refrigerant low-pressure-cutoff set point in psig.

- n. Refrigerant high-pressure-cutoff set point in psig.
- 6. Refrigerant Test Data (Indicated and Actual Values):
 - a. Oil level.
 - b. Refrigerant level.
 - c. Relief valve setting in psig.
 - d. Unloader set points in psig.
 - e. Percentage of cylinders unloaded.
 - f. Bearing temperatures in deg F.
 - g. Vane position.
 - h. Low-temperature-cutoff set point in deg F.
- O. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:
 - 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Unit make and model number.
 - d. Compressor make.
 - e. Compressor model and serial numbers.
 - f. Refrigerant weight in lb.
 - g. Low ambient temperature cutoff in deg F.
 - 2. Test Data (Indicated and Actual Values):
 - a. Inlet-duct static pressure in inches wg.
 - b. Outlet-duct static pressure in inches wg.
 - c. Entering-air, dry-bulb temperature in deg F.
 - d. Leaving-air, dry-bulb temperature in deg F.
 - e. Condenser entering-water temperature in deg F.
 - f. Condenser leaving-water temperature in deg F.
 - g. Condenser-water temperature differential in deg F.
 - h. Condenser entering-water pressure in feet of head or psig.
 - i. Condenser leaving-water pressure in feet of head or psig.
 - j. Condenser-water pressure differential in feet of head or psig.
 - k. Control settings.
 - l. Unloader set points.
 - m. Low-pressure-cutout set point in psig.
 - n. High-pressure-cutout set point in psig.
 - o. Suction pressure in psig.
 - p. Suction temperature in deg F.
 - q. Condenser refrigerant pressure in psig.
 - r. Condenser refrigerant temperature in deg F.
 - s. Oil pressure in psig.
 - t. Oil temperature in deg F.
 - u. Voltage at each connection.
 - v. Amperage for each phase.
 - w. Kilowatt input.
 - x. Crankcase heater kilowatt.
 - y. Number of fans.
 - z. Condenser fan rpm.
 - aa. Condenser fan airflow rate in cfm.
 - bb. Condenser fan motor make, frame size, rpm, and horsepower.
 - cc. Condenser fan motor voltage at each connection.
 - dd. Condenser fan motor amperage for each phase.
- P. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
 - 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Service.

- d. Make and size.
 - e. Model and serial numbers.
 - f. Water flow rate in gpm.
 - g. Water pressure differential in feet of head or psig.
 - h. Required net positive suction head in feet of head or psig.
 - i. Pump rpm.
 - j. Impeller diameter in inches.
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.
 - o. Full-load amperage and service factor.
 - p. Seal type.
2. Test Data (Indicated and Actual Values):
- a. Static head in feet of head or psig.
 - b. Pump shutoff pressure in feet of head or psig.
 - c. Actual impeller size in inches.
 - d. Full-open flow rate in gpm.
 - e. Full-open pressure in feet of head or psig.
 - f. Final discharge pressure in feet of head or psig.
 - g. Final suction pressure in feet of head or psig.
 - h. Final total pressure in feet of head or psig.
 - i. Final water flow rate in gpm.
 - j. Voltage at each connection.
 - k. Amperage for each phase.

Q. Boiler Test Reports:

- 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and type.
 - e. Model and serial numbers.
 - f. Fuel type and input in Btuh.
 - g. Number of passes.
 - h. Ignition type.
 - i. Burner-control types.
 - j. Voltage at each connection.
 - k. Amperage for each phase.
- 2. Test Data (Indicated and Actual Values):
 - a. Operating pressure in psig.
 - b. Operating temperature in deg F.
 - c. Entering-water temperature in deg F.
 - d. Leaving-water temperature in deg F.
 - e. Number of safety valves and sizes in NPS.
 - f. Safety valve settings in psig.
 - g. High-limit setting in psig.
 - h. Operating-control setting.
 - i. High-fire set point.
 - j. Low-fire set point.
 - k. Voltage at each connection.
 - l. Amperage for each phase.
 - m. Draft fan voltage at each connection.
 - n. Draft fan amperage for each phase.
 - o. Manifold pressure in psig.

R. Air-to-Air Heat-Recovery Unit Reports:

- 1. Unit Data:
 - a. Unit identification.
 - b. Location.

- c. Service.
- d. Make and type.
- e. Model and serial numbers.
- 2. Motor Data:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
- 3. If fans are an integral part of the unit, include the following for each fan:
 - a. Make and type.
 - b. Arrangement and size.
 - c. Sheave make, size in inches, and bore.
 - d. Sheave dimensions, center-to-center, and amount of adjustments in inches.
- 4. Test Data (Indicated and Actual Values):
 - a. Total exhaust airflow rate in cfm.
 - b. Purge exhaust airflow rate in cfm.
 - c. Outside airflow rate in cfm.
 - d. Total exhaust fan static pressure in inches wg.
 - e. Total outside-air fan static pressure in inches wg.
 - f. Pressure drop on each side of recovery wheel in inches wg.
 - g. Exhaust air temperature entering in deg F.
 - h. Exhaust air temperature leaving in deg F.
 - i. Outside-air temperature entering in deg F.
 - j. Outside-air temperature leaving in deg F.
 - k. Calculate sensible and total heat capacity of each airstream in MBh.

S. Instrument Calibration Reports:

- 1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.25 INSPECTIONS

A. Initial Inspection:

- 1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
- 2. Randomly check the following for each system:
 - a. Measure airflow of at least 10 percent of air outlets.
 - b. Measure water flow of at least 5 percent of terminals.
 - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - d. Measure sound levels at two locations.
 - e. Measure space pressure of at least 10 percent of locations.
 - f. Verify that balancing devices are marked with final balance position.
 - g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

- 1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Engineer.
- 2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner, Architect, and/or Construction Manager.

3. Engineer shall select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.26 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.
- C. 11 Month Warranty Walk: TAB to perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to report unusual conditions with recommendations of adjustments. TAB Contractor shall allow two days for this work.

END OF SECTION 23 05 93

SECTION 23 09 93 - HVAC SEQUENCE OF OPERATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The provisions of the General Conditions, Sections included under Division 1, General Requirements, and Section 23 05 00 of this Division are included as a part of this Section as though bound herein.
- B. Refer to Division 01 Section "Alternates" that may affect the Work of this Section.
- C. Refer to the details and schedules on the Drawings for additional requirements.
- D. Refer to specifications for additional requirements.

1.2 SECTION INCLUDES

- A. This Section includes the sequences of operation for the HVAC equipment and systems.
- B. The Temperature Control Contractor shall read all other Drawings and Specifications, become familiar with requirements and scope of the Project, and include such coordination work as may be required.
- C. Sequences of operation shall meet or exceed the requirements of ASHRAE standard 90.1.

1.3 SUBMITTALS

- A. Submittals are required and shall include detailed descriptions of the proposed sequence of operations for all HVAC systems specific to the project.

1.4 BUILDING SET POINTS

- A. All set points and other variables noted in the sequences are to be adjustable from the web accessible graphical user interface so that the owner does not have to go to the school or open any programming software to change the settings. Access to the adjustable settings shall be password protected and an audit log shall track who made what changes and when they were made.
- B. Refer to sequence of operations of individual equipment for set points specific to each designated zone.

Winter Design:

<u>Occupied Mode</u>	<u>Unoccupied Mode</u>
70 deg. F	55 deg. F

Summer Design:

<u>Occupied Mode</u>	<u>Unoccupied Mode</u>
75 deg. F, 60 percent RH	85 deg. F, 60 percent RH

1.5 EXISTING SEQUENCE OF OPERATIONS

- A. The Temperature Controls Contractor shall verify all existing sequence of operations for all equipment prior to removing existing controls. The following sequence of operations are intended to be adapted as required to accommodate existing conditions. The Temperature Controls Contractor shall prepare sequence of operations for all equipment and review those sequences with the Architect/Engineer and Owner. Sequence of Operations review meetings shall be scheduled a minimum of 10 days prior to the meeting to allow all required parties to participate.

1.6 SEQUENCE OF OPERATION

A. Boilers and Heating Water Pumps

1. Provide a microprocessor based direct digital control system that shall provide the following:
 - a. Boilers and heating water pumps shall be enabled from the BAS, to operate based on the following outside air temperature schedule by the BAS. Boilers and pumps operation, supply and return temperature, and flow shall be monitored and alarmed through the BAS, via integration with the equipment.
 - b. The boilers shall have a boiler controller furnished by the Temperature Control Contractor. The boiler controller shall interface directly to the BMS system. Coordinate with the boiler manufacturer for information on point scaling, override, and set-point control capabilities.
 - c. Mounting and wiring of the boiler controller shall be provided by the Contractor.
 - d. All available point information from the heating water system shall be routed to the BAS.
 - e. The boilers high and low temperature alarms, low water cutoff, flow switch, and flame failure shall be routed to the BAS.
 - f. The pump status shall be monitored by a current sensing relay. If the lead pump fails to start or is not confirmed within two minutes after the command to start has been initiated through the BAS, the standby pump shall be indexed to start and an alarm shall be initiated.
 - g. Provide automatic alternating lead/lag operation through the BAS.
 - h. The building heating water supply temperature sensor and the outside air temperature sensor, through the DDC/BAS output signal, shall modulate the heating water supply temperature to maintain the following supply temperature reset schedule in a linear sequence.

<u>Heating Water Supply Temperature</u>	<u>O.A. Temperature</u>
180 Degrees F (adj.)	<20 degrees F (adj.)
180 Degrees F (adj.)	60 degrees F (adj.)
180 Degrees F (adj.)	Above 60 degrees F (adj.)

- i. The heating water temperature reset shall be controlled by the use of a system 3-way temperature reset valve if the system utilizes non-condensing boilers. The water temperature shall not create condensing situations in non-condensing boilers.
- j. The Contractor to furnish flow switch, and temperature sensors for heating water system required by boiler manufacturer, and instruct Installing Contractor on proper location and proper installation of the temperature sensors. The Contractor to wire between all devices and control panels.
- k. When the heating water system is enabled, the lead boiler module shall start and fire. The unit shall increase input until the input reaches a point of 65 percent input (Transfer Set Point - adjustable). Upon a reduced heating demand, the lead boiler shall decrease input to match building load. Upon a continued heating demand, the lead boiler shall be held at the Transfer set point for a delayed time of 10 minutes (adj.), at which point the boiler controller shall prepare to start the next boiler by decreasing the input on the first boiler to minimum firing rate. At this point, the next boiler shall enable to minimum firing rate. All firing boilers inputs shall continue to increase equally to increase the heating water system temperature as required by the BAS system.
- l. The isolation valve associated with the lead boiler shall be open at all times. The isolation valves associated with the lag boilers shall be open for 5 minutes (adj.) prior to energizing the lag boiler, and shall remain open to 10 minutes (adj.) after boiler(s) are disabled. All isolation valves are to be fail "OPEN".

- m. Upon a reduced heating demand, with multiple boilers firing, boilers shall decrease inputs equally until all firing boilers are at minimum firing rate for a delayed time of 2 minutes (adj.) as which point the boiler controller shall disable the latest added boiler. The remaining boiler(s) shall increase or decrease inputs as required until a boiler is to be enabled or disabled based on the Transfer Points – in which case the above scenarios are to occur.
- n. Boiler inputs shall be modulated down in response to the BAS in a reverse manner. Each boiler shall come off line at the transfer set-point to maximize the condensing of the boiler system, when the system utilizes condensing boilers.
- o. Boilers shall automatically be alternated as the lead boiler based on equal run time hours, and season.
- p. Each boiler shall operate a minimum of 10 minutes (adj.) and turn off for a minimum of 5 minutes (adj.).
- q. Primary pumps or variable speed heating water pumps shall run a minimum of 2 minutes (adj.) prior to enabling it's associated boiler, and shall remain running for a minimum of 10 minutes (adj.) after the associated boiler has been disabled.
- r. If the lead boiler fails to start when energized by the BAS system, a lag boiler shall start. At this time an alarm shall be initiated through the BAS system.
- s. The lead heating water pump, either primary or variable speed heating water pump) shall run continuously.
- t. A variable frequency controller for each heating pump, either secondary or variable speed heating water pump, shall vary pump speed in response to differential pressure sensors located in the heating water system. VFC shall respond to sensor with the lowest pressure. Upon enable, the lead pump will start and be proven by the pump differential switch. The DDC Controller will monitor differential pressure between the heating water supply and return lines in locations as denoted on the Drawings. The DDC Controller will increase or decrease the pump speed to maintain the desired set-point at the lowest pressure point. Upon lead pump obtaining 100 percent speed for 10 minutes (adj.), the lag pump will start. The DDC Controller will increase or decrease the pump speeds so that each pump is providing 50 percent of the system flow. Should the pumps fall below 50 percent speed for a minimum of 10 minutes (adj.), the lag pump will turn off and the lead pump speed will be controlled to maintain set-point.
- u. Provide temperature sensors, differential pressure sensors, flow meter, wiring and programming of all devices to the BAS system. Coordinate with other trades for proper balancing and start-up of system. Coordinate boiler controller interface with boiler manufacturer.
- v. The Building Automation System shall automatically start/stop and alternate pumps with the "off" pump as a backup, should the lead pump fail.
- w. The minimum speed for the heating water pumps shall be as required to maintain the minimum flow rate through the boilers as required by the unit manufacturer, or the minimum flow rate recommended by the pump manufacturer, whichever flow rate is larger. The rate of speed change on the heating water pumps shall not exceed the requirements of the boiler manufacturer. Contractor shall be responsible to provide additional bypass if the boiler purchased can't meet the minimum water flows listed in the schedule.
- x. Small boilers only shall be energized along with heating water pumps shall be enabled any time that any of the systems are in dehumidification mode.
- y. Boiler plant and hot water pumps are to be monitored for dehumidification mode. The BAS shall generate an alarm and not permit the units to enter the dehumidification mode because it detects that the Hot Water System is not enabled, or in alarm, and cannot provide the reheat necessary for dehumidification. A visible graphic to be displayed on the BAS.
- z. Upon alarm of all boilers in the heating plant, with the outside air temperature above 50 degrees F and the chillers energized, the hot water pumps are to be commanded "OFF" to prevent the heating water from extracting cooling at the reheat coils.

- B. Water Chillers (outdoor, air-cooled chillers)
1. The chillers shall be supplied complete with all operating and safety controls. The Contractor shall wire the flow switch supplied (or differential pressure sensor) by the chiller manufacturer. The conduit and wiring from the outdoor chiller control panel to the chiller interface panel located in the mechanical room shall be by the Contractor.
 2. The chillers shall be provided with open protocol communication boards for full communication via BACnet. This contractor shall coordinate exact requirements with chiller manufacturer. The chiller manufacturer must provide submittals to the Contractor of all wiring diagrams and points lists including override capability and scaling values. The chiller manufacturer shall provide all software CD's, licenses, and connections tools to the Contractor for setup and servicing, which is to be turned over to the owner at project completion.
 3. The BAS shall enable the chiller control circuit and the chilled water pumps on a call for cooling anytime the outdoor air temperature is above 50 degrees (adj.). The chiller control panel shall prove flow through the chiller before allowing chiller to operate. Pressure transducers and interlock wiring shall be furnished and installed by the Contractor. Flow switch (or internal differential pressure sensor) provided by chiller manufacturer.
 4. Once energized, the chiller shall automatically operate to maintain required water temperature, based on chilled water supply temperature set-point reset, down to 44 degrees F. (adj.).
 5. Chilled Water Supply Temperature – Set-point Reset:
The chilled water supply temperature set-point shall reset using a trim and respond algorithm based on cooling requirements. The chilled water supply temperature set-point shall reset to a lower value (44 degrees F – adj.) as the facility's chilled water valves open beyond a user definable threshold (90% open, adj.). Once the chilled water coils are satisfied (valves closing below 90% open, adj.) then the chilled water supply temperature set-point shall gradually rise over time to reduce cooling energy use. Maximum set-point to be 50 degrees F (adj.).
 6. Lock out the chiller system below 50 degrees F (adj.). outside air temperature during occupied mode, and during "unoccupied" sequence from the BAS.
 7. The mechanical cooling system shall be locked out in "unoccupied" sequence unless building zone temperature rises above 85 degrees F (adj.) or 60 percent relative humidity (adj.).
 8. Provide sensors in the building chilled water supply and return for indication through the Global Control Panel.
 9. Temperature Control Contractor shall install chiller interface panel, provide wiring between chiller and panel, and provide all wiring and programming required to communicate with the chiller interface panel. Chiller interface panel furnished by the chiller manufacturer. Provide a specific graphics screen on the BAS for all points provided through the chiller interface panel. Coordinate communications protocol with chiller manufacturer. The following chiller control functions shall be accessible through the central BAS:
 - a. Chilled water inlet temperature
 - b. Chilled water outlet temperature
 - c. Chilled water flow
 - d. Evaporator refrigerant pressure
 - e. Evaporator refrigerant temperature
 - f. Evaporator approach temperature
 - g. Condenser refrigerant pressure
 - h. Condenser refrigerant temperature
 - i. Compressor refrigerant discharge temperature
 - j. Percent RLA
 - k. Compressor running status
 - l. Manual reset alarm occurrence
 - m. Communication status
 - n. Chiller enable/disable
 - o. Chiller water set-point
 - p. Demand limit set-point

10. The BAS will enable the chiller upon either of the following conditions.
 - a. The outside air temperature is above 50 degrees (adj.) and any HVAC zone is an occupied state.
 - b. The outside air temperature is above 80 degrees (adj.) all HVAC zones are in an unoccupied state, and the average HVAC zone temperature is above 85 degrees (adj.).
 11. The BAS will enable the lead chilled water pump along with the chiller.
 12. Once the chiller is enabled, it will prove flow via the interlocked flow switch and automatically operate chiller to maintain a leaving water temperature of chilled water supply temperature – set-point reset, down to 44 degrees F. (adj.).
 13. Chilled Water Pumps
 - a. The BAS will enable the primary chilled water pumps, either primary or variable speed chilled water pumps, when there is a command for their associated chiller to be operational. The primary chilled water pumps shall remain enabled for a period of 5 minutes (adj.) after the chillers have been disabled.
 - b. Upon enable, the lead pump will start and be proven on. The DDC Controller will monitor differential pressure between the chilled water supply and return lines in locations as denoted on the Drawings. The DDC Controller will increase or decrease the pump speed to maintain the desired set-point at the lowest pressure point. Upon lead pump obtaining 100 percent speed for 10 minutes (adj.), the lag pump will start. The DDC Controller will increase or decrease the pump speeds so that each pump is providing 50 percent of the system flow. Should the pumps fall below 65 percent speed (adj.), for a minimum of 10 minutes (adj.), the lag pump will turn off and the lead pump speed will be controlled to maintain set-point.
 - c. The chilled water pumps shall modulate to maintain the minimum required chiller differential pressure required by unit manufacturer.
 - d. Provide automatic weekly alternating lead/lag operation through the BAS to maintain equal runtimes of the pumps. Provide a software lead/lag override switch in the graphics for the owner to use during pump service.
 - e. The minimum speed for the variable speed chilled water pumps shall be as required to maintain the minimum flow rate through the chiller as required by the unit manufacturer, or the minimum flow rate recommended by the pump manufacturer, whichever flow rate is larger. The rate of speed change on the chilled water pumps shall not exceed the requirements of the chiller manufacturer.
 - f. The Building Automation System shall automatically start/stop and alternate pumps with the “off” pump as a backup, should the lead pump fail.
- J. Variable Air Volume Terminal Unit Controllers
1. Fan Powered VVF Terminal Units
 - a. The system shall be enabled with an optimum start schedule 2 hours maximum (adj.) prior to the start of occupied mode.
 - b. The supply fan shall be started 5 minutes (adj.) prior to the air handling unit supply fan.
 - c. The VAV terminal fan shall run continuously during occupied cycle. During unoccupied cycle, the fan shall cycle to maintain a reduced night temperature setting.
 - d. A wall-mount electronic temperature sensor shall modulate the terminal unit primary air damper in sequence with the heating coil control valve to maintain space temperature.
 - e. When morning warm up is initiated by the Building Automation System, the VAV controller assumes the occupied mode of operation, enables the terminal fan, reverses the control action of the damper to modulate the air flow between maximum flow and reheat minimum flow values to maintain the zone temperature. The heating valve supplements the warm air available from the air handling unit. When the zone temperature reaches setpoint the system will automatically index to occupied cycle.

- f. During occupied operation, the primary air damper shall be modulated to maintain space setpoint. Minimum setting of air damper shall be as scheduled on Drawings. On a continued drop in space temperature at minimum air, the heating water valve shall be modulated open to maintain desired space temperature. Occupied space setpoint shall be 75 (adj.) for cooling and 70 (adj.) degrees for heating.
 - g. If space temperature drops more than 5 degrees F below occupied setpoint during the occupied period, primary air damper shall close completely, heating water control valve shall open fully and fan shall run. When space setpoint is reached, terminal unit shall return to full occupied operation.
 - h. The Contractor shall provide and install a discharge air sensor in the discharge airstream of VAV terminals. The sensor valves shall be included on the graphic screen for the terminal.
 - i. During unoccupied cycle, the primary air damper shall be closed tight, the heating valve modulated and the fan cycled as required to maintain reduced space setpoint. Unoccupied space setpoint shall be 55 degrees (adj.) in winter and 85 degrees (adj.) in summer.
2. VVR Reheat Terminal Units
- a. The system shall be enabled with an optimum start schedule 2 hours maximum (adj.) prior to the start of occupied mode.
 - b. During occupied cycle, a wall-mount electronic temperature sensor shall modulate the primary air damper to maintain space temperature. On a drop in space temperature below set point, the primary air damper shall modulate to its 50% position and the heating coil control valve will modulate open as required to maintain space set point. On a continued drop in space temperature, the heating coil control valve shall remain open and the primary air valve shall modulate from 50% airflow to maximum airflow as required to maintain space temperature. Conversely, on a rise in space temperature, the heating coil control valve shall close and the primary air damper shall modulate as required to maintain set point.
 - c. During the unoccupied cycle, the primary air damper shall be closed. If space temperature is below unoccupied heating space set point, associated control zone(s) shall be energized and VVR terminals primary air damper shall be set to 50% open for all terminal units in zone. The heating coil control valve shall be modulated as required to maintain unoccupied set-point. If space temperature is above unoccupied cooling space set point, associated control zone(s) shall be energized and VVR terminals primary air damper shall be set to maximum airflow for all terminal units in zone. Once unoccupied set points have been achieved for 30 min. (adj.) associated air handling units shall shut down and VVR terminal primary air damper shall close.
 - d. When morning warm-up is initiated by the Building Automation System, the VVR controller assumes the occupied mode of operation, reverses the control action of the damper to modulate the air flow between maximum flow and reheat 50% flow values to maintain the zone temperature. The heating valve supplements the warm air available from the air handling unit. When the zone temperature reaches set-point, the system will automatically index to occupied cycle.
 - e. The Contractor shall provide and install a discharge air sensor in the discharge airstream of VAV terminals. The sensor value shall be included on the graphic screen for the terminal.
3. The Contractor shall graphically display variable air volume terminal information in a matrix format, for each terminal unit associated with a given air handling unit. Matrix to include(at a minimum):
- a. VAV Box Description
 - b. Room Name (or space being served)
 - c. VAV Box Mode of operation
 - d. Space temperature
 - e. Space set-points (heating / cooling)
 - f. VAV airflow

- g. VAV airflow set-point
- h. VAV Box Damper position
- i. VAV Box % cooling
- j. VAV Box % heating
- k. VAV Box entering air temperature (From associated AHU).
- l. VAV Box leaving air temperature.

K. Self-Contained Cooling Units

- 1. The Contractor shall mount and wire thermostat provided by unit manufacturer. Control sequence shall be part of unit mounted. Upon a drop in room temperature, the supply fan shall cycle on and the heating water control valve shall modulate to maintain room temperature set point. Minimum outside air dampers shall open during occupied hours when supply fan is operating. Provide interconnecting wiring between evaporator unit and condensing unit. Monitor room temperature through the central BAS panel and alarm if room temperature rises above 85F (adj.) degrees.

L. Variable Frequency Controller.

- 1. The Building Automation System shall monitor alarms and outputs from the VFC, via BACnet Communication Interface.

M. Carbon Monoxide Detector

- 1. Provide a carbon monoxide detector in rooms with gas fired equipment and monitor through the building automation system. Detector shall send an alarm signal to the building automation system any time the carbon monoxide level exceeds 35 ppm (adj.).

N. Boiler Room Emergency Shut-Down

- 1. Provide an emergency shut-down button switch in the boiler room to shut-down all gas-fired equipment upon activation.
- 2. Emergency shut-down button switch shall be located near the door in the path of egress from the boiler room.
- 3. Activation of the emergency shut-down switch shall send an alarm to the building automation system.
- 4. Coordinate shutdown of power to boilers with electrical contractor.

O. Fire Alarm

- 1. Coordinate with Division 26 Electrical Contractor and provide necessary contacts to shut down all mechanical equipment during a fire alarm. The system shall be capable of restarting equipment globally upon a "no alarm signal" from the fire alarm panel.

P. Critical Alarms

- 1. Critical alarms shall dial or send text to personal cell telephones, personal home telephones, and send email messages to school district employees as determined by the school corporation. Alarms shall be setup and active prior to building occupancy. The following will be considered critical alarms:
 - a. Any boiler alarm.
 - b. Any circulation pump failure
 - c. Any technology room temperature above 85 degrees F.
 - d. Any other alarm deemed critical by the school corporation and/or Architect/Engineer.
 - e. Refer to all sequences of operation for additional alarms.

END OF SECTION 23 09 93

SECTION 23 21 13 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
 - 1. Hot-water heating piping.
 - 2. Chilled-water piping.
- B. Related Sections include the following:
 - 1. Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.
 - 2. Division 23 Section "Polypropylene Hydronic Piping Option"
 - a. The polypropylene hydronic piping option can be bid as an option to copper and or black steel piping for heating and chilled water systems. Approved fittings and connectors shall be used to transition to all valves and accessories. Refer to Section 23 21 14.

1.2 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
 - 1. Hot-Water Heating Piping: 125 psig at 200 deg F.
 - 2. Chilled-Water Piping: 125 psig at 200 deg F.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
 - 2. Chemical treatment.
 - 3. Hydronic specialties.
 - 4. Grooved fittings and joint couplings, provide applicable styles used.

1.4 CLOSEOUT SUBMITTALS

- A. General: Closeout Submittals are to be submitted with O and M Manuals only. Do not submit with other ACTION and INFORMATIONAL Submittals.
 - 1. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
- B. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

- D. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
 - 1. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped or identified for quality assurance and traceability.
- E. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

1.6 EXTRA MATERIALS

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Grooved-Copper Fittings option: ASME B16.22.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Tyco-Grinnell
 - b. Anvil Gruvlok.
 - c. Victaulic Company of America.
 - 2. Grooved-End Copper Fittings: ASME B16.22 wrought copper and ASTM B 75, copper tube or ASME B16.18 and ASTM B 584, bronze casting, manufactured to copper tube dimensions. Flaring of tube or fitting ends to accommodate alternate sized couplings is not permitted.
 - 3. Grooved-End-Tube Couplings: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, EHP gasket rated for maximum 250 deg F for use with housing, and electroplated steel bolts and nuts.
- D. Copper or Bronze Pressure-Seal Fittings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Stadler-Viega (Propress)
 - b. Nibco
 - c. Elkhart
 - 2. Housing: Copper.
 - 3. O-Rings and Pipe Stops: EPDM.
 - 4. Tools: Manufacturer's special tools.
 - 5. Minimum 200-psig working-pressure rating at 250 deg F.
- E. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. T-DRILL Industries Inc.
- F. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
- H. Grooved Mechanical-Joint Fittings and Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Tyco-Grinnell.
 - b. Anvil Gruvlok.
 - c. Victaulic Company of America.
 - 2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 234, Grade WPB steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 - 3. Couplings: Rigid pattern, unless otherwise indicated, ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 - a. NPS 2 through NPS 12:
 - 1) Rigid Type: Housings shall be cast with bolt pads to provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9.
 - a) NPS 2 through NPS 6: Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket rated to +230 deg. F.
 - b) Zero-Flex Style.
 - 2) Flexible Type: For use in locations where vibration attenuation and stress relief air required. Three flexible couplings may be used in lieu of a flexible connector. The couplings shall be placed in close proximity to the source of the vibration.
 - 3) Flange Adapter: Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components.
 - b. 14 inch through 24 inch with lead-in chamfer on housing key and wide width FlushSeal® gasket.
 - 1) Rigid Type: Housing key shall fill the wedge shaped AGS groove and provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9.
 - 2) Flexible Type: Housing key shall fit into the wedge shaped AGS groove and allow for linear and angular pipe movement.
 - 3) Flange Adapter: Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components.
- I. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.3 PVC PIPE AND FITTINGS

- A. PVC Material: The material used in the manufacture of the pipe shall be a rigid polyvinyl chloride (PVC) compound, Type I Grade I, with a Cell Classification of 12454 as defined in ASTM D1784. This compound shall be light gray in color.
- B. Pipe Dimensions: All sizes of PVC Schedule 80 pipe shall be manufactured by and ISO 9001 certified manufacture in strict accordance to the requirements of ASTM D1785 for physical dimensions and tolerances. Each production run of pipe manufactured in compliance to the standard, shall also meet or exceed the test requirements for materials, workmanship, burst pressure, flattening, and extrusion quality defined in ASTM D1785.
- C. Pipe Markings: Product marking shall meet the requirements of ASTM D1785 and shall include: the manufacturer's name (or the manufacturer's trademark when privately labeled); the nominal pipe size; the material designation code; the pipe schedule and pressure rating in PSI for water @ 73°F; the ASTM designation D1785.
- D. Threaded metal to plastic connections are not permitted. Where transitions between plastic and metal pipe and fittings occur, compression style metal to plastic unions, flanges, or grooved connections shall be utilized.
- E. Grooved Mechanical-Joint Fittings and Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Tyco-Grinnell.
 - b. Anvil Gruvlok.
 - c. Victaulic Company of America.
 - 2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 234, Grade WPB steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 - 3. Couplings: Rigid pattern, unless otherwise indicated, ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 - a. NPS 2 through NPS 12:
 - 1) Flexible Type: For use in locations where vibration attenuation and stress relief air required. Three flexible couplings may be used in lieu of a flexible connector. The couplings shall be placed in close proximity to the source of the vibration.

2.4 CPVC PIPE AND FITTINGS

- A. CPVC Material: The material used in the manufacture of the pipe shall be a rigid polyvinyl chloride (PVC) compound, Type IV Grade I, with a Cell Classification of 23447 as defined in ASTM D1784. This compound shall be light gray in color.
- B. Pipe Dimensions: All sizes of CPVC Schedule 80 pipe shall be manufactured in strict accordance to the requirements of ASTM F 441 for physical dimensions and tolerances. Each production run of pipe manufactured in compliance to the standard, shall also meet or exceed the test requirements for materials, workmanship, burst pressure, flattening, and extrusion quality defined in ASTM D1784.
- C. Pipe Markings: Product marking shall meet the requirements of ASTM F 441 and shall include: the manufacturer's name (or the manufacturer's trademark when privately labeled); the nominal pipe size; the material designation code; the pipe schedule and pressure rating in PSI for water @ 73°F; the ASTM designation D1784.

2.5 POLYPROPYLENE RESIN (PP-R) PIPE AND FITTINGS

- A. Pipe shall be manufactured from a PP-R resin meeting the short-term properties and long-term strength requirements of ASTM F 2389 or CSA B137.11. The pipe shall contain no rework or recycled materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. All pipe shall be made in a three layer extrusion process. Hydronic hot water and heating piping shall contain a fiber layer (faser) to restrict thermal expansion. All pipe shall comply with the rated pressure requirements of ASTM F 2389 or CSA B137.11. All pipe shall be certified by NSF International as complying with NSF 14, and ASTM F 2389 or CSA B137.11. Pipe shall be Aquatherm® Climatherm® as manufactured by Aquatherm, Inc.
- B. Fittings shall be manufactured from a PP-R resin meeting the short-term properties and long-term strength requirements of ASTM F 2389. The fittings shall contain no rework or recycled materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. All fittings shall be certified by NSF International as complying with NSF 14, and ASTM F 2389 or CSA B137.11. Fittings shall be Aquatherm® Climatherm® as manufactured by Aquatherm, Inc.
- C. Installation of polypropylene resin (PP-R) piping, fittings, and system components shall be in strict accordance with the manufacture written instructions.

2.6 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- E. Grooved Joint Lubricants: Lubricate gaskets in accordance with the manufacturer's recommendations with lubricant supplied by the coupling manufacturer that is suitable for the gasket elastomer and system media.
- F. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.
- H. PVC solvent Joints: Solvent-cemented joints should be utilized in a two step process with primer manufactured for thermoplastic piping systems conforming to ASTM F656 and solvent cement conforming to ASTM 2564. Primer shall be clear. Solvent-cement shall be clear, medium-bodied and medium-setting and formulated for PVC piping.
- I. CPVC solvent joints: Solvent-cemented joints should be utilized in a two step process with primer manufactured for thermoplastic piping systems and solvent cement conforming to ASTM F493. Primer shall be clear. Solvent-cement shall be clear, medium-bodied and medium-setting and formulated for CPVC piping.

2.7 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Hart Industries International, Inc.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.
 - 2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.
- D. Dielectric Flanges:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 2. Factory-fabricated companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
- E. Dielectric-Flange Kits:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - 3. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.
- F. Dielectric Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Calpico, Inc.
 - b. Lochinvar Corporation.
 - 2. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
- G. Dielectric Nipples:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Tyco-Grinnell
 - b. Anvil Gruvlok
 - c. Perfection Corporation; a subsidiary of American Meter Company.
 - d. Precision Plumbing Products, Inc.
 - e. Sioux Chief Manufacturing Company, Inc.
 - f. Victaulic Company of America.
 - 2. Electroplated steel nipple or ductile iron casing with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.8 VALVES

- A. Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."
- B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section "Instrumentation and Control for HVAC."
- C. Bronze, Calibrated-Orifice, Balancing Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong Pumps, Inc.
 - b. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - c. Flow Design Inc.
 - d. Griswold Controls.
 - e. Taco.
 - f. Nexus.
 - g. Tour & Andersson.
 - h. Tyco-Grinnell.
 - i. Victaulic Company
 - 2. Body: Bronze or a metal copper alloy, ball, globe, or plug type with calibrated orifice or venturi.
 - 3. Ball: Brass or stainless steel.
 - 4. Disc: A metal copper-alloy.
 - 5. Plug: Resin.
 - 6. Seat: PTFE or EPDM.
 - 7. End Connections: Threaded or socket.
 - 8. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
 - 9. Handle Style:
 - a. Lever, with memory stop to retain set position.
 - b. Hand wheel, with memory stop to retain set position.
 - 10. CWP Rating: Minimum 300 psig.
 - 11. Maximum Operating Temperature: 230 deg F.
 - 12. Valve shall be selected between 2 and 6 feet water pressure drop. Verify optimal sizing with manufacturer.
- D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong Pumps, Inc.
 - b. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - c. Flow Design Inc.
 - d. Griswold Controls.
 - e. Taco.
 - f. Nexus.
 - g. Tour & Andersson; available through Victaulic Company of America.
 - h. Tyco-Grinnell.
 - i. Victaulic Company
 - 2. Body: Cast-iron, ductile iron, or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
 - 3. Ball: Brass or stainless steel.
 - 4. Stem Seals: EPDM O-rings.
 - 5. Disc: A metal copper-alloy or glass and carbon-filled PTFE.
 - 6. Seat: PTFE or EPDM.
 - 7. End Connections: Flanged or grooved.
 - 8. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
 - 9. Handle Style:
 - a. Lever, with memory stop to retain set position.
 - b. Hand wheel, with memory stop to retain set position.
 - 10. CWP Rating: Minimum 250 psig.
 - 11. Maximum Operating Temperature: 230 deg F.

12. Valve shall be selected between 2 and 6 feet water pressure drop. Verify optimal sizing with manufacturer.

E. Diaphragm-Operated, Pressure-Reducing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - d. Conbraco Industries, Inc.
 - e. Spence Engineering Company, Inc.
 - f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Sized for a maximum operating temperature 225 degrees F.
11. Sized for a maximum operating pressure of 125 psig.
12. Valve Size and Capacity: Selected to suit system in which installed. Refer to detail in Contract Documents.
13. Operating Pressure: Inlet pressure up to 300 psig. Outlet pressure field adjustable from 10 to 35 psig.

F. Diaphragm-Operated Safety Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - d. Conbraco Industries, Inc.
 - e. Spence Engineering Company, Inc.
 - f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bell & Gossett Domestic Pump; a Division of ITT Industries.
 - b. Flow Design Inc.
 - c. Nexus
 - d. Griswold Controls.
2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.

7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig.
9. Maximum Operating Temperature: 200 deg F.
10. Valve size to be selected between 2 and 6 feet water pressure drop (WPD). Verify optimal sizing to minimize pressure drop with unit manufacturer.
11. Removable flow cartridge.

2.9 AIR CONTROL DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Amtrol, Inc.
 2. Armstrong Pumps, Inc.
 3. Bell & Gossett Domestic Pump; a division of ITT Industries.
 4. Taco.
 5. Wessels.
- B. Manual Air Vents:
 1. Body: Bronze.
 2. Internal Parts: Nonferrous.
 3. Operator: Screwdriver or thumbscrew.
 4. Inlet Connection: NPS 1/2.
 5. Discharge Connection: NPS 1/8.
 6. CWP Rating: 150 psig.
 7. Maximum Operating Temperature: 225 deg F.
- C. Automatic Air Vents:
 1. Body: Bronze or cast iron.
 2. Internal Parts: Nonferrous.
 3. Operator: Noncorrosive metal float.
 4. Inlet Connection: NPS 1/2.
 5. Discharge Connection: NPS 1/4.
 6. CWP Rating: 150 psig.
 7. Maximum Operating Temperature: 240 deg F.
- D. Expansion Tanks:
 1. Tank: Welded steel, rated for 125-psig working pressure and 240 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gauge glass. Tanks shall be factory tested with taps fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 2. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.
 3. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.
 4. Gauge Glass: Full height with dual manual shutoff valves, 3/4-inch diameter gauge glass, and slotted-metal glass guard.
- E. Diaphragm or Bladder-Type Expansion Tanks:
 1. Tank: Welded steel, rated for 125-psig working pressure and 240 deg F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 2. Diaphragm or Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
 3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
- F. Tangential-Type Air Separators:

1. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
4. Blowdown Connection: Threaded.
5. Size: Match system flow capacity.

G. In-Line Air Separators:

1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 psig.
3. Maximum Operating Temperature: Up to 300 deg F.

H. Combination Air Eliminator and Dirt Separator – Option in lieu of installing air separator and side loop filter.

1. Performance Requirements:
 - a. Air Separation: Removal of 99.6 percent of entrained air in the system.
 - b. Dirt Separation: Removal of 80 percent of all particles 30 micron and larger with 100 passes.
2. Coalescing type air eliminator and dirt separator equal to Spirovent by Spirotherm, or approved equal.
 - a. Air eliminator and dirt separator to be sized for schedule water flow and will replace the air separator only for chilled water system. The aluminum bag filter to be installed from drain outlet of air eliminator and dirt separator to downstream side to reintroduce clean glycol back into the chilled water system.
 - b. All details for the air separator will apply to air eliminator and dirt separator.
 - c. All cost and manufacturer requirements are to be included under base bid if option is to be pursued.

I. Performance Requirements

1. Air Separation:
 - a. 100 percent of free air.
 - b. 100 percent entrained air.
 - c. Removal of 99.6 percent of dissolved air in the system.
2. Dirt Separation:
 - a. Removal of 80 percent of all particles 30 micron and larger within 100 passes.
3. Coalescing medium to extend full length of shell filling the entire vessel with no open space or voids between them to suppress turbulence and provide high efficiency. Partial fill units are not acceptable.
 - a. Coalescing medium to be copper or stainless steel.
4. Combination air eliminator and dirt separator to be sized for schedule water flows.
5. Rated for 150 psig working pressure.
6. Maximum entering water velocity to be less than 10 feet per second.
7. Accessories:
 - a. Blow-down valve
 - b. Skim valve
 - c. Automatic air vent

J. Air Purgers:

1. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
2. Maximum Working Pressure: 150 psig.
3. Maximum Operating Temperature: 250 deg F.

2.10 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 536, Grade 65-45-12, ductile iron with coupled cover or ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.

2. End Connections: Threaded ends for NPS 2 and smaller; grooved or flanged ends for NPS 2-1/2 and larger.
 3. Strainer Screen: 40 or 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent total free area.
 4. CWP Rating: 300 psig.
 5. Include blow down valve with cap and chain.
- B. Stainless-Steel Bellow, Flexible Connectors:
1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
 2. End Connections: Threaded or flanged to match equipment connected.
 3. Performance: Capable of 3/4-inch misalignment.
 4. CWP Rating: 150 psig.
 5. Maximum Operating Temperature: 250 deg F.
 6. Three flexible style couplings may be used in lieu of flexible connectors for vibration attenuation and stress relief for services to 230 deg. F. The couplings shall be placed in close proximity to the source of the vibration.
- C. Spherical, Rubber, Flexible Connectors:
1. Body: Fiber-reinforced rubber body.
 2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
 3. Performance: Capable of misalignment.
 4. CWP Rating: 150 psig.
 5. Maximum Operating Temperature: 250 deg F.
 6. Three flexible style couplings may be used in lieu of flexible connectors for vibration attenuation and stress relief for services to 230 deg. F. The couplings shall be placed in close proximity to the source of the vibration.
- D. Expansion fittings are specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure-seal joints.
 2. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
- B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure seal joints.
 2. Type L, drawn-temper copper tubing, grooved, mechanical joint coupling and fittings, and grooved mechanical joints.
 3. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 4. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
- C. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure-seal joints.
 2. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
- D. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure seal joints.

2. Type L, drawn-temper copper tubing, grooved, mechanical joint coupling and fittings, and grooved, mechanical joints.
3. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
4. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

3.2 VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.
- B. Install calibrated-orifice, balancing valves at each branch connection to return main as denoted on Drawings.
- C. Install calibrated-orifice, balancing valves or automatic flow control valves in the return pipe of each heating or cooling terminal as denoted on Drawings.
- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01, for installation requirements.
- F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.
- G. Insulation: Where insulation is indicated, install extended stem valves arranged in a proper manner to receive insulation.

3.3 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.

- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
 - L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap and chain, at low points in piping system mains and elsewhere as required for system drainage.
 - M. Reduce pipe sizes using eccentric reducer fitting installed with level side up for horizontal piping.
 - N. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."
 - O. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
 - P. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
 - 1. Unions or flanges are not required in installations using grooved mechanical joint couplings. (The couplings shall serve as unions and disconnect points).
 - Q. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2. All strainers shall contain blow down valve.
 - R. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."
 - 1. For water systems, use adequate numbers of flexible style couplings in header piping to accommodate thermal growth and contraction, and for the elimination of expansion loops. (In accordance with coupler manufacturer instructions and as approved by the engineer.) Where expansion loops are required, use flexible style couplings on the loops.
 - S. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."
 - T. Freeze Protection
 - 1. Do not install any hydronic piping which includes domestic cold and hot water, fire and sprinkler water, chilled water, heating water, condenser water piping, etc. within 12 feet of an exterior wall or roof opening utilized for fresh air intake or building relief air.
 - 2. Any piping installed closer than 12 feet of an exterior wall or roof opening shall be moved or rerouted around the perimeter of the opening in order to prevent possible freezing of hydronic piping.
 - U. Install dielectric fittings as specified between connections of all dissimilar metals.
- 3.4 HANGERS AND SUPPORTS
- A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.
 - B. Seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
 - C. Pipe attachments shall be located adjacent to fittings at each offset or change in direction, at ends of branches over 5 feet long, at riser pipes, and along piping where necessary to prevent sags, bends, or vibration. Piping risers shall be supported at each floor level.
 - D. Hanger rod must hang perpendicular before and after pipe covering or insulation is applied.

1. Support piping from rolled steel beams or channels from any point on either top or bottom flanges.
2. Support piping from open web steel joists from hangers connected to either top or bottom chords within 3 inches of center of chord panel points (intersection of diagonal or vertical chord with top or bottom chord). Joist reinforcement will be required if hangers are not installed at panel points. Refer to structural details.
3. In addition to maximum spacing of hangers or supports specified below, the number and spacing of hangers and supports shall be such as to equally distribute loads to all structural members in the system.
4. Connections to structural members shall be clamping devices which do not damage or deform structural elements. Welding to or drilling holes in structural members is not permitted unless specifically approved by Architect.
5. Threaded rod shall not be bent. Provide swivel connection or other means to prevent stress on threaded rod.

E. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

F. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.
8. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2 inch.
9. NPS 8: Maximum span, 19 feet; minimum rod size, 5/8 inch.
10. NPS 10: Maximum span, 20 feet; minimum rod size, 3/4 inch.
11. NPS 12: Maximum span, 23 feet; minimum rod size, 7/8 inch.
12. NPS 14: Maximum span, 25 feet; minimum rod size, 1 inch.
13. NPS 16: Maximum span, 27 feet; minimum rod size, 1 inch.
14. NPS 18: Maximum span, 28 feet; minimum rod size, 1-1/4 inches.
15. NPS 20: Maximum span, 30 feet; minimum rod size, 1-1/4 inches.

G. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.

H. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

I. In grooved installations, use rigid couplings with offsetting angle-pattern bolt pads, which permit support and hanging in accordance with ANSI B31.1, B31.3, and B31.9.

3.5 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- I. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
 - 1. Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions.
 - 2. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
 - 3. Gaskets shall be of an elastomer grade suitable for the intended service, and shall be molded and produced by the coupling manufacturer.
 - 4. The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products.
 - a. The representative shall periodically visit the jobsite and review contractor is following best recommended practices in grooved product installation. (A distributor's representative is not considered qualified to conduct the training of jobsite visit(s).)
- J. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.
- K. Pressure-Sealed Joints: Use manufacturer-recommended PFT series tool and procedure. Leave insertion marks on pipe after assembly.

3.6 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.
- C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
- D. Install tangential air separator in pump suction. Install blowdown piping with full-port ball valve; extend full size to nearest floor drain.

- E. Install welded steel type expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
 - 1. Install tank fittings that are shipped loose.
 - 2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.
- F. Install bladder or diaphragm type expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.

3.7 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install ports for pressure gauges and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gauges for HVAC Piping."

3.8 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens. All piping in the entire building is to be flushed, regardless of installation method.
 - a. Clean water shall be water that has been through the permanent project softener and permanent project domestic water filtration, or from an approved public water supply, by A/E.
 - b. All rooms, branch piping, and equipment will be isolated prior to initiating flush/clean/fill.
 - c. The main piping will be filled with clean water and mild cleaning agents.
 - d. A water quality sample will be taken by the chemical treatment company.
 - e. The drain valve(s) at the end of each pipe run will be opened, with a hose routed outside the building.
 - f. Utilizing the main circulating pumps, this water will be re-circulated for a minimum of 48 hours.
 - g. After initial flush, this water will be removed and the process repeated until water sample is deemed acceptable by F/H and CxA.
 - h. Once the main piping is approved clean, the drain valves to each room or branch will be opened individually until clean water is flowing from the drain valve.
 - i. The individual strainers will be removed, cleaned, and reinstalled. Multiple strainer cleanings may be required during the flush/clean/fill procedure.
 - j. At that point, the isolation valves to each room will be opened and the total system will be filled.
 - k. Utilizing the main circulating pumps, this water will be re-circulated for a minimum of 48 hours.
 - l. The drain valves to each room or branch will be opened individually until clean water is flowing from the drain valve.
 - m. The individual strainers will be removed, cleaned, and reinstalled. Multiple strainer cleanings may be required during the flush/clean/fill procedure.
 - n. The process is to be repeated until water sample is deemed acceptable by F/H and/or CxA.
 - 4. Isolate all equipment and all equipment coils from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
6. Corrosion inhibitor to be applied after flushing and before filling the piping system.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

3.9 PREPARATION AND CLEANING PROCEDURES

A. Preparation

1. Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.
2. Place terminal control valves in open position during cleaning.

B. Cleaning Sequence

1. Add cleaner to closed systems at concentration recommended by manufacturer. Hot Water Heating Systems: Apply heat while circulating, slowly raising temperature to 160 degrees F and maintain for 12 hours minimum. Remove heat and circulate to 100 degrees F or less; drain systems as quickly as possible and refill with clean water. Circulate for 6 hours at design temperatures, then drain. Refill with clean water and repeat until system cleaner is removed.
2. Chilled Water Systems: Circulate for 48 hours, then drain systems as quickly as possible. Refill with clean water, circulate for 24 hours, then drain. Refill with clean water and repeat until system cleaner is removed.
3. Use neutralizer agents on recommendation of system cleaner supplier and approval of A/E.
4. Remove, clean, and replace strainer screens.
5. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

C. Closed System Treatment and Cleaning

1. Provide one shot feeder on each system. Install isolating and drain valves and necessary piping. Install around circulating pumps unless indicated otherwise.

D. Refer to Division 23 Section 232500 – HVAC Water Treatment for additional requirements.

END OF SECTION 23 21 13

SECTION 23 25 00 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following HVAC water-treatment systems:
 - 1. Glycol feed equipment and controls.
 - 2. Chemical treatment test equipment.
 - 3. HVAC water-treatment chemicals.
 - 4. Water filtration units for HVAC makeup water.

1.2 DEFINITIONS

- A. EEPROM: Electrically erasable, programmable read-only memory.
- B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- C. TDS: Total dissolved solids.

1.3 PERFORMANCE REQUIREMENTS

- A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

1.4 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:
 - 1. Bypass feeders.
 - 2. Automatic glycol feeders.
 - 3. Side-loop filters.
- B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: Power and control wiring.

1.5 INFORMATIONAL/QUALITY ASSURANCE/CONTROL SUBMITTALS

- A. Other Informational Submittals:
 - 1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.
 - 2. Water Analysis: Illustrate water quality available at Project site.
 - 3. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.6 CLOSEOUT DOCUMENTS

- A. General: Closeout Submittals are to be submitted with O and M Manuals only. Do not submit with other ACTION and INFORMATIONAL Submittals:

1. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.8 MAINTENANCE SERVICE

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, biological growth, and glycol concentration for cooling chilled-water piping, heating-hot-water piping, heating, steam and condensate piping, condenser-water piping, and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:
 1. Initial water analysis and HVAC water-treatment recommendations.
 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
 3. Periodic field service and consultation. Test systems every 2 months, unless noted otherwise.
 4. Customer report charts and log sheets.
 5. Laboratory technical analysis.
 6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Ampion Corp.
 2. Anderson Chemical Co, Inc.
 3. Aqua-Chem, Inc.; Cleaver-Brooks Div.
 4. Aqua-Science
 5. Barclay Chemical Co.; Water Management, Inc.
 6. Boland Trane Services
 7. Don Chemical Co.
 8. Enerco
 9. GE Betz.
 10. GE Osmonics.
 11. H-O-H Chemicals, Inc.
 12. Interstate Chemical Company, Inc.
 13. Marathon/Chem-Aqua
 14. Metro Group. Inc. (The); Metropolitan Refining Div.
 15. Ohio Chemical
 16. ONDEO Nalco Company.
 17. Protocol
 18. Union Carbide Corp.
 19. Watcon, Inc.
 20. Chardon Labs

2.2 CHEMICAL TREATMENT TEST EQUIPMENT

- A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems.

2.3 CHEMICALS

- A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 "Performance Requirements" Article.

2.4 PROPYLENE GLYCOL-BASED PRODUCT

- A. The heat transfer fluid shall be an inhibited ethylene glycol-based individual heat transfer fluid specifically formulated for use in HVAC and ICE BANK SYSTEMS. The fluid must contain corrosion inhibitors and buffers and an antifoam agent, necessary for long fluid and system life.
- B. The 30 percent solution of heat transfer fluid and deionized water, premixed by the chemical manufacturer, shall have a freezing point of 9 degrees F., a burst point of -11 degrees F., a specific gravity of 1.061 at 20/20 degrees C., no flash point, no silicates, and fluorescent orange color.
- C. The weight per gallon of premixed fluid shall be 8.78 lbs./gal. at 68 degrees F. The specific heat shall be 0.935 BTU/lb. degrees F. at 25 degrees F. and 0.941 BTU/lb. degrees F. at 68 degrees F.
- D. Field or distributor mixed fluid, automotive antifreeze, uninhibited glycol, or field or distributor inhibited glycol is not acceptable.
- E. Acceptable Manufacturers: Subject to compliance with requirements, provide premixed 30 percent propylene glycol by one of the following:
 1. Dow Chemical Co.: Dowfrost HD.
 2. Union Carbide Corp.: Ucar Protherm - 30.
 3. Interstate: Intercool NFP.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

- A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.
- B. Install water testing equipment on wall near water chemical application equipment.
- C. Install interconnecting control wiring for chemical treatment controls and sensors.
- D. Mount sensors and injectors in piping circuits.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

- C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Division 23 Section "Common Work Results for HVAC."
- D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Division 23 Section "General-Duty Valves for HVAC Piping."
- E. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.
- F. Confirm applicable electrical requirements in Division 26 Sections for connecting electrical equipment.
- G. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- H. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
 - 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 - 7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 - 8. Repair leaks and defects with new materials and retest piping until no leaks exist.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article for each required characteristic. Sample boiler water at eight-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.

- F. At eight-week intervals following Substantial Completion and during warranty period, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article.

- G. Comply with ASTM D 3370 and with the following standards:
 - 1. Silica: ASTM D 859.
 - 2. Acidity and Alkalinity: ASTM D 1067.
 - 3. Iron: ASTM D 1068.
 - 4. Water Hardness: ASTM D 1126.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 25 00

SECTION 23 31 13 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg. Metal ducts include the following:
1. Rectangular ducts and fittings.
 2. Single-wall, round, and flat-oval spiral-seam ducts and formed fittings.
 3. Double-wall, round, and flat-oval spiral-seam ducts and formed fittings.
 4. Duct liner.
- B. Related Sections include the following:
1. Division 07 Section "Penetration Firestopping."
 2. Division 09 Section "Interior Painting."
 3. Division 23 Section "Nonmetal Ducts" for fibrous-glass ducts, thermoset FRP ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
 4. Division 23 Section "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
 5. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 DEFINITIONS

- A. NUSIG: National Uniform Seismic Installation Guidelines.

1.3 SYSTEM DESCRIPTION

- A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by A/E. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.4 ACTION SUBMITTALS

- A. Shop Drawings: Drawn to 1/4 inch equals 1 foot scale. Show fabrication and installation details for metal ducts.
1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 2. Duct layout indicating sizes and pressure classes.
 3. Elevations of top and bottom of ducts.
 4. Dimensions of main duct runs from building grid lines.
 5. Fittings.
 6. Reinforcement and spacing.
 7. Seam and joint construction.
 8. Penetrations through fire-rated and other partitions.
 9. Equipment installation based on equipment being used on Project.
 10. Duct accessories, including access doors and panels.
 11. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.
- B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Ceiling suspension assembly members.
 2. Other systems installed in same space as ducts.
 3. Ceiling- and wall-mounting access doors and panels required to provide access to dampers and other operating devices.

4. Ceiling-mounting items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. In general, the piping and ductwork shown on the drawings shall be considered as diagrammatic for clearness in indicating the general run and connections required, and may not be shown in its true position. The piping and ductwork equipment may have to be offset, lowered, or raised as required to accommodate field conditions.

1.5 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports, AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members, and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. NFPA Compliance:
 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- C. Comply with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations," Ch. 3, "Duct System," for range hood ducts, unless otherwise indicated.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. PVC-Coated Galvanized Steel: Acceptable by authorities having jurisdiction for use in fabricating ducts with UL 181, Class 1 listing. Lock-forming-quality, galvanized sheet steel complying with ASTM A 653 and having G60 coating designation. Factory-applied PVC coatings shall be 4 mils thick on sheet metal surfaces of ducts and fittings exposed to corrosive conditions and 2 mils thick on opposite surfaces.
- D. Carbon-Steel Sheets: ASTM A 366, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.
- E. Stainless Steel: ASTM A480, Type 304 and having a No. 20 finish for concealed ducts, and a finish to match kitchen or dishwasher hoods for exposed ducts.
- F. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- G. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

- H. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 DUCT LINER

- A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
 - 1. Manufacturers:
 - a. CertainTeed Corp.; Insulation Group.
 - b. Johns Manville International, Inc.
 - c. Knauf Fiber Glass GmbH.
 - d. Owens Corning.
 - 2. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
 - a. Thickness: 1 inch.
 - b. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
 - c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - 1) For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - e. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.
 - 1) Tensile Strength: Indefinitely sustain a 50-lb tensile, dead-load test perpendicular to duct wall.
 - 2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
 - 3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

2.4 SEALANT MATERIALS

- A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
 - 1. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
- C. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.
- D. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.
- E. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
- F. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.5 HANGERS AND SUPPORTS

- A. Hanger Materials: Galvanized sheet steel or threaded steel rod.
 - 1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
 - 2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.

3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.
- B. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
 - C. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
 3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.
 - D. Contractor may use load rated cable suspension system. Suspension system shall have a specified manufacturers safe working load and supplemental safety factor of at least five times the safe working load.
 1. Suspension system shall be verified by SMACNA Testing and Research Institute to be in compliance with SMACNA Duct Construction Standards Guidelines (1995 CH.4).
 2. Acceptable Manufacturers:
 - a. Dura-Dyne
 - b. Gripple

2.6 RECTANGULAR DUCT FABRICATION

- A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
 2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.
 1. Manufacturers:
 - a. Ductmate Industries, Inc.
 - b. Nexus Inc.
 - c. Ward Industries, Inc.
- C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.
 1. Manufacturers:
 - a. Ductmate Industries, Inc.
 - b. Lockformer.
 2. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.
 3. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.
- D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of nonbraced panel area unless ducts are lined.

2.7 APPLICATION OF LINER IN RECTANGULAR DUCTS

- A. The net free area of the duct dimensions on the Contract Documents shall be maintained. Increase metal duct dimensions as necessary to compensate for addition of the liner.
- B. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

- C. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
- D. Butt transverse joints without gaps and coat joint with adhesive.
- E. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- F. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- G. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm
- H. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
- I. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - 1. Fan discharges.
 - 2. Intervals of lined duct preceding unlined duct.
 - 3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm or where indicated.
- J. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.8 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

- A. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.
- B. Round, Longitudinal- and Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- C. Flat-Oval, Spiral Lock-Seam Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- D. Duct Joints:
 - 1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
 - 2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
 - 3. Ducts Larger Than 72 Inches in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.
 - 4. Round Ducts: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances.
 - a. Manufacturers:
 - 1) Ductmate Industries, Inc.
 - 2) Lindab Inc.
 - 5. Flat-Oval Ducts: Prefabricated connection system consisting of two flanges and one synthetic rubber gasket.
 - a. Manufacturers:
 - 1) Ductmate Industries, Inc.
 - 2) McGill AirFlow Corporation.
 - 3) SEMCO Incorporated.

- E. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.
- F. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.
- G. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
 - 1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
 - 2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg:
 - a. Ducts 3 to 36 Inches in Diameter: 0.034 inch.
 - b. Ducts 37 to 50 Inches in Diameter: 0.040 inch.
 - c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
 - d. Ducts 62 to 84 Inches in Diameter: 0.064 inch.
 - 3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg:
 - a. Ducts 3 to 26 Inches in Diameter: 0.034 inch.
 - b. Ducts 27 to 50 Inches in Diameter: 0.040 inch.
 - c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
 - d. Ducts 62 to 84 Inches in Diameter: 0.064 inch.
 - 4. Flat-Oval Mitered Elbows: Welded construction with same metal thickness as longitudinal-seam flat-oval duct.
 - 5. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
 - 6. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
 - 7. Round Elbows 9 through 14 Inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
 - 8. Round Elbows Larger Than 14 Inches in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
 - 9. Die-Formed Elbows for Sizes through 8 Inches in Diameter and All Pressures 0.040 inch thick with 2-piece welded construction.
 - 10. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
 - 11. Flat-Oval Elbow Metal Thickness: Same as longitudinal-seam flat-oval duct specified above.
 - 12. Pleated Elbows for Sizes through 14 Inches in Diameter and Pressures through 10-Inch wg: 0.022 inch.
- H. PVC-Coated Elbows and Fittings: Fabricate elbows and fittings as follows:
 - 1. Round Elbows 4 to 8 Inches in Diameter: Two piece, die stamped, with longitudinal seams spot welded, bonded, and painted with PVC aerosol spray.
 - 2. Round Elbows 9 to 26 Inches in Diameter: Standing-seam construction.
 - 3. Round Elbows 28 to 60 Inches in Diameter: Standard gored construction, riveted and bonded.
 - 4. Other Fittings: Riveted and bonded joints.
 - 5. Couplings: Slip-joint construction with a minimum 2-inch insertion length.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

- A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
 - 1. Supply Ducts: 2-inch wg.
 - 2. Supply Ducts (before Air Terminal Units): 3-inch wg.
 - 3. Supply Ducts (after Air Terminal Units): 2-inch wg.
 - 4. Return Ducts (Negative Pressure): 1-inch wg.
 - 5. Exhaust Ducts (Negative Pressure): 2-inch wg.
- B. All ducts shall be galvanized steel.

3.2 DUCT INSTALLATION

- A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- B. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.
- C. Install ducts with fewest possible joints.
- D. Install fabricated fittings for changes in directions, size, and shape and for connections.
- E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.
- F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.
- J. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.
- K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.
- N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section "Air Duct Accessories." Firestopping materials and installation methods are specified in Division 07 Section "Penetration Firestopping."

- O. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" or NUSIG.
 - P. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."
 - Q. Paint interiors of metal ducts, that do not have duct liner, for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.
 - R. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. **[Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."]**
- 3.3 PVC-COATED DUCT, SPECIAL INSTALLATION REQUIREMENTS
- A. Repair damage to PVC coating with manufacturer's recommended materials.
- 3.4 SEAM AND JOINT SEALING
- A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated. **[and in compliance with ASHRAE/IESNA 90.1].**
 - 1. For pressure classes lower than 2-inch wg, seal transverse joints.
 - B. Seal ducts before external insulation is applied.
- 3.5 HANGING AND SUPPORTING
- A. Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Chapter 5, "Hangers and Supports," unless otherwise noted.
 - B. Support horizontal ductwork runs on 6 foot centers and within 24 inches of each elbow and within 48 inches of each branch intersection. Where duct weight for the 6 foot length is less than 40 pounds, support hangers may be on 8 foot centers.
 - C. Support vertical ducts at maximum intervals of 16 feet and at each floor.
 - D. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
- 3.6 CONNECTIONS
- A. Make connections to equipment with flexible connectors according to Division 23 Section "Air Duct Accessories."
 - B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.
- 3.7 FIELD QUALITY CONTROL
- A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports. Leak testing is required for all medium pressure ductwork rated with a static-pressure class that exceeds 2-inch wg. Low-pressure ductwork rated below 2-inch wg will not require pressure testing.
 - 1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round and flat-oval ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2-inch wg (both positive and negative pressures), and Leakage Class 6 for pressure classes from 2- to 10-inch wg.
4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

3.8 CLEANING NEW SYSTEMS

- A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.
- B. Use service openings, as required, for physical and mechanical entry and for inspection.
 1. Create other openings to comply with duct standards.
 2. Disconnect flexible ducts as needed for cleaning and inspection.
 3. Remove and reinstall ceiling sections to gain access during the cleaning process.
- C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.
- D. Clean the following metal duct systems by removing surface contaminants and deposits:
 1. Air outlets and inlets (registers, grilles, and diffusers).
 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 4. Coils and related components.
 5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
 6. Supply-air ducts, dampers, actuators, and turning vanes.
 7. Dedicated exhaust and ventilation components and makeup air systems.
- E. Mechanical Cleaning Methodology:
 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet.
 5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 6. Provide drainage and cleanup for wash-down procedures.
- F. Cleanliness Verification:
 1. Visually inspect metal ducts for contaminants.
 2. Where contaminants are discovered, re-clean and reinspect ducts.

3.9 CLEANING EXISTING SYSTEMS

- A. Use service openings, as required, for physical and mechanical entry and for inspection.
 - 1. Use existing service openings where possible.
 - 2. Create other openings to comply with duct standards.
 - 3. Disconnect flexible ducts as needed for cleaning and inspection.
 - 4. Reseal rigid fiberglass duct systems according to NAIMA recommended practices.
 - 5. Remove and reinstall ceiling sections to gain access during the cleaning process.
- B. Mark position of dampers and air-directional mechanical devices before cleaning, and restore to their marked position on completion.
- C. Particulate Collection and Odor Control:
 - 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron size (or larger) particles.
 - 2. When venting vacuuming system to the outside, use filtration to contain debris removed from HVAC system, and locate exhaust down wind and away from air intakes and other points of entry into building.
- D. Clean the following metal duct systems by removing surface contaminants and deposits:
 - 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.
 - 5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
 - 6. Supply-air ducts, dampers, actuators, and turning vanes.
 - 7. Dedicated exhaust and ventilation components and makeup air systems.
- E. Mechanical Cleaning Methodology:
 - 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 - 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
 - 5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 - 6. Provide operative drainage system for washdown procedures.
 - 7. Biocidal Agents and Coatings: Apply biocidal agents if fungus is present. Apply biocidal agents according to manufacturer's written instructions after removal of surface deposits and debris.
- F. Cleanliness Verification:
 - 1. Verify cleanliness after mechanical cleaning and before application of treatment, including biocidal agents and protective coatings.
 - 2. Visually inspect metal ducts for contaminants.
 - 3. Where contaminants are discovered, re-clean and reinspect ducts.
- G. Gravimetric Analysis: At discretion and expense of Owner, sections of metal duct system, chosen randomly by Owner, may be tested for cleanliness according to NADCA vacuum test gravimetric analysis.

1. If analysis determines that levels of debris are equal to or lower than suitable levels, system shall have passed cleanliness verification.
 2. If analysis determines that levels of debris exceed suitable levels, system cleanliness verification will have failed and metal duct system shall be re-cleaned and re-verified.
- H. Verification of Coil Cleaning: Cleaning must restore coil pressure drop to within 10 percent of pressure drop measured when coil was first installed. If original pressure drop is not known, coil will be considered clean only if it is free of foreign matter and chemical residue, based on thorough visual inspection.

END OF SECTION 23 31 13

SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Backdraft and pressure relief dampers.
 - 2. Manual volume dampers.
 - 3. Flange connectors.
 - 4. Turning vanes.
 - 5. Duct-mounted access doors.
 - 6. Flexible connectors.
 - 7. Flexible ducts.
 - 8. Duct accessory hardware.
- B. Related Sections:
 - 1. Division 23 Section "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
 - 2. Division 28 Section "Fire Detection and Alarm" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.
- C. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with AMCA 500-D testing for damper rating.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304.

- D. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- E. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Air Balance Inc.; a division of Mestek, Inc.
 2. American Warming and Ventilating; a Division of Mestek, Inc.
 3. Cesco Products; a division of Mestek, Inc.
 4. Duro Dyne Inc.
 5. Greenheck Fan Corporation.
 6. Lloyd Industries, Inc.
 7. Nailor Industries Inc.
 8. NCA Manufacturing, Inc.
 9. Pottorff; a division of PCI Industries, Inc.
 10. Ruskin Company.
 11. SEMCO Incorporated
 12. Vent Products Company, Inc.
- B. Description: Gravity balanced.
- C. Maximum Air Velocity: 2000 fpm.
- D. Maximum System Pressure: 1-inch wg.
- E. Frame: 0.063-inch thick [**extruded aluminum**], with welded corners and mounting flange.
- F. Blades: Multiple single-piece blades, maximum 6-inch width, 0.025-inch thick, roll-formed aluminum with sealed edges.
- G. Blade Action: Parallel.
- H. Blade Seals: Extruded vinyl, mechanically locked.
- I. Blade Axles:
 1. Material: Aluminum.
 2. Diameter: 0.20 inch.
- J. Tie Bars and Brackets: Aluminum.
- K. Return Spring: Adjustable tension.
- L. Bearings: Steel ball or synthetic pivot bushings.
- M. Accessories:
 1. Adjustment device to permit setting for varying differential static pressure.
 2. Counterweights and spring-assist kits for vertical airflow installations.
 3. Electric actuators.
 4. Chain pulls.
 5. Front or rear screens.
 6. 90-degree stops.

N. Sleeve: Minimum 20-gauge thickness.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance Inc.; a division of Mestek, Inc.
 - b. American Warming and Ventilating; a division of Mestek, Inc.
 - c. Flexmaster U.S.A., Inc.
 - d. McGill AirFlow LLC.
 - e. METALAIRE, Inc.
 - f. Nailor Industries Inc.
 - g. Pottorff; a division of PCI Industries, Inc.
 - h. Ruskin Company.
 - i. Trox USA Inc.
 - j. Vent Products Company, Inc.
2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:
 - a. Hat-shaped, galvanized-steel channels, 0.064-inch minimum thickness.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
 - a. Multiple or single blade.
 - b. Parallel blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized-steel, 0.064 inch thick.
6. Blade Axles: Galvanized steel.
7. Bearings:
 - a. Oil-impregnated bronze or molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
8. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance Inc.; a division of Mestek, Inc.
 - b. American Warming and Ventilating; a division of Mestek, Inc.
 - c. Flexmaster U.S.A., Inc.
 - d. McGill AirFlow LLC.
 - e. METALAIRE, Inc.
 - f. Nailor Industries Inc.
 - g. Pottorff; a division of PCI Industries, Inc.
 - h. Ruskin Company.
 - i. Trox USA Inc.
 - j. Vent Products Company, Inc.
2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frame for installing in ducts.
5. Blades:
 - a. Multiple or single blade.
 - b. Parallel-blade design.
 - c. Stiffen damper blades for stability.
 - d. Roll-Formed Aluminum Blades: 0.10-inch thick aluminum sheet.
6. Blade Axles: Nonferrous metal.
7. Bearings:
 - a. Oil-impregnated bronze or molded synthetic.

- b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
- 8. Tie Bars and Brackets: Galvanized steel.

C. Low-Leakage, Steel, Manual Volume Dampers:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance Inc.; a division of Mestek, Inc.
 - b. American Warming and Ventilating; a division of Mestek, Inc.
 - c. Flexmaster U.S.A., Inc.
 - d. McGill AirFlow LLC.
 - e. METALAIRE, Inc.
 - f. Nailor Industries Inc.
 - g. Pottorff; a division of PCI Industries, Inc.
 - h. Ruskin Company.
 - i. Trox USA Inc.
 - j. Vent Products Company, Inc.
- 2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
- 3. Suitable for horizontal or vertical applications.
- 4. Frames:
 - a. Hat-shaped
 - b. Galvanized-steel channels, 0.064 inch thick.
 - c. Mitered and welded corners.
 - d. Flanges or attaching to walls and flangeless frames for installing in ducts.
- 5. Blades:
 - a. Multiple or single blade.
 - b. Parallel-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized, roll-formed steel, 0.064 inch thick.
- 6. Blade Axles: Galvanized steel.
- 7. Bearings:
 - a. Oil-impregnated bronze or molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
- 8. Blade Seals: Vinyl.
- 9. Jamb Seals: Flexible metal.
- 10. Tie Bars and Brackets: Galvanized steel.
- 11. Accessories:
 - a. Include locking device to hold single-blade dampers in a fixed position without vibration.

D. Low-Leakage, Aluminum, Manual Volume Dampers:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance Inc.; a division of Mestek, Inc.
 - b. American Warming and Ventilating; a division of Mestek, Inc.
 - c. Flexmaster U.S.A., Inc.
 - d. McGill AirFlow LLC.
 - e. METALAIRE, Inc.
 - f. Nailor Industries Inc.
 - g. Pottorff; a division of PCI Industries, Inc.
 - h. Ruskin Company.
 - i. Trox USA Inc.
 - j. Vent Products Company, Inc.
- 2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
- 3. Suitable for horizontal or vertical applications.
- 4. Frames: Hat-shaped, 0.10-inch thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
- 5. Blades:

- a. Multiple or single blade.
 - b. Parallel-blade design.
 - c. Roll-Formed Aluminum Blades: 0.10-inch thick aluminum sheet.
 - 6. Blade Axles: Nonferrous metal.
 - 7. Bearings:
 - a. Oil-impregnated bronze or molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - 8. Blade Seals: Vinyl.
 - 9. Jamb Seals: Cambered aluminum.
 - 10. Tie Bars and Brackets: Aluminum.
 - 11. Accessories:
 - a. Include locking device to hold single-blade dampers in a fixed position without vibration.
- E. Jackshaft:
- 1. Size: 1-inch diameter.
 - 2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 - 3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.
- F. Damper Hardware:
- 1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
 - 2. Include center hole to suit damper operating-rod size.
 - 3. Include elevated platform for insulated duct mounting.

2.4 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. Ductmate Industries, Inc.
 - 2. Nexus PDQ; Division of Shilco Holdings Inc.
 - 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gauge and Shape: Match connecting ductwork.

2.5 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. Ductmate Industries, Inc.
 - 2. Duro Dyne Inc.
 - 3. METALAIRE, Inc.
 - 4. SEMCO Incorporated.
 - 5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."
- D. Vane Construction: Double wall.

2.6 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. American Warming and Ventilating; a division of Mestek, Inc.
 2. Cesco Products; a division of Mestek, Inc.
 3. Ductmate Industries, Inc.
 4. Flexmaster U.S.A., Inc.
 5. Greenheck Fan Corporation.
 6. McGill AirFlow LLC.
 7. Nailor Industries Inc.
 8. Pottorff; a division of PCI Industries, Inc.
 9. Ventfabrics, Inc.
 10. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - d. Fabricate doors airtight and suitable for duct pressure class.
 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.
- C. Pressure Relief Access Door:
1. Door and Frame Material: Galvanized sheet steel.
 2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
 3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
 4. Factory set at **[10-inch wg]<Insert value>**.
 5. Doors close when pressures are within set-point range.
 6. Hinge: Continuous piano.
 7. Latches: Cam.
 8. Seal: Neoprene or foam rubber.
 9. Insulation Fill: 1-inch thick, fibrous-glass or polystyrene-foam board.

2.7 DUCT ACCESS PANEL ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ductmate Industries, Inc.
 2. Flame Gard, Inc.
 3. 3M.
- B. Labeled according to UL 1978 by an NRTL.
- C. Panel and Frame: Minimum thickness 0.0528-inch carbon or 0.0428-inch stainless steel.
- D. Fasteners: Carbon or stainless steel. Panel fasteners shall not penetrate duct wall.

- E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.
- F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.8 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Duro Dyne Inc.
 - 3. Ventfabrics, Inc.
 - 4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Materials: Flame-retardant or noncombustible fabrics.
- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F.
- F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd..
 - 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F.
- G. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
 - 1. Minimum Weight: 14 oz./sq. yd..
 - 2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F
- H. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
 - 1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 - 2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 - 7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.9 FLEXIBLE DUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Atco
 - 2. Flexmaster U.S.A., Inc.

3. Hercules Industries, Inc.
 4. McGill AirFlow LLC.
 5. Tuttle & Bailey; A Division of Hart & Cooley, Inc.
 6. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Low Pressure Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.
1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
 2. Maximum Air Velocity: 4000 fpm.
 3. Temperature Range: Minus 20 to plus 175 deg F.
- C. **[High][Medium]** Pressure Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; **[polyethylene] [aluminized]** vapor-barrier film.
1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
 2. Maximum Air Velocity: 4000 fpm.
 3. Temperature Range: Minus 20 to plus 210 deg F.
- D. Flexible Duct Connectors:
1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action or nylon strap in sizes 3 through 18 inches, to suit duct size.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers at discharge of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
1. Coordinate subparagraphs below with Division 23 Section "Metal Ducts." Install steel volume dampers in steel ducts.
 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
1. On both sides of duct coils.
 2. Downstream from control dampers and equipment.
 3. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 4. At all backdraft damper locations.

5. At all airflow measuring stations.
 6. Elsewhere as indicated.
- H. Install access doors with swing against duct static pressure.
- I. Access Door Sizes:
1. One-Hand or Inspection Access: 8 by 5 inches.
 2. Two-Hand Access: 12 by 6 inches.
 3. Head and Hand Access: 18 by 10 inches.
 4. Head and Shoulders Access: 21 by 14 inches.
 5. Body Access: 25 by 14 inches.
 6. Body plus Ladder Access: 25 by 17 inches.
- J. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- K. Install flexible connectors to connect ducts to equipment.
- L. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- M. Flexible duct shall not be acceptable for use in exhaust system or negative pressure applications.
- N. Connect terminal units to supply ducts with maximum 12-inch lengths of medium pressure flexible duct. Do not use flexible ducts to change directions.
- O. Connect diffusers to low-pressure ducts with maximum 15 foot lengths of flexible duct clamped or strapped in place.
- P. Connect flexible ducts to metal ducts with draw bands.
- Q. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
1. Operate dampers to verify full range of movement.
 2. Inspect locations of access doors and verify that purpose of access door can be performed.
 3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
 4. Inspect turning vanes for proper and secure installation.
 5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 33 00

SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.
- B. Related Sections include the following:
 - 1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
 - 2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.2 ACTION SUBMITTALS

- A. Product Data: For each product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
 - a. A-J Manufacturing Co., Inc.
 - b. Anemostat; a Mestek Company.
 - c. Carnes.
 - d. Dayus Register & Grille.
 - e. Hart & Cooley, Inc.; Hart & Cooley Div.
 - f. Krueger.
 - g. METALAIR, Inc.; Metal Industries Inc.
 - h. Nailor Industries of Texas Inc.
 - i. Price Industries.
 - j. Titus.
 - k. Tuttle & Bailey.

2.2 AIR TRANSFER GRILLES, RETURN GRILLES, AND EXHAUST GRILLES (TYPE C)

- A. All aluminum construction.
- B. 35 degree louvers spaced 1/2 inch on center.
- C. One set of fixed louvers parallel to long dimension.
- D. Baked white enamel or powder paint white finish for ceiling installation. Provide wall mounted and exposed duct mounted installation with primed finish for field painting.
- E. Size of grille as indicated on Drawings.

2.3 SQUARE PANEL CEILING DIFFUSER (Type A,B)

- A. All 18 gauge steel diffuser, 24 inch by 24 inch module size, 18 inch by 18 inch face panel.

- B. Round neck connection, dimension as scheduled on Drawings.
- C. Solid face panel with curved back pan designed for VAV usage. Face panel shall be easily removed.
- D. Back pan shall be one-piece die-formed with smooth surfaces and no corner joints.
- E. Baked white enamel finished unless otherwise denoted on Drawings.
- F. Provide blank-off plates to convert diffuser to 2-way or 3-way blow where indicated on Drawings.
- G. Equivalent to Titus "Omni."

2.22 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13

SECTION 23 81 23 - COMPUTER-ROOM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following types of computer-room air-conditioning units:
 - 1. Ceiling-mounting units.
 - 2. Console units.

1.2 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.

1.3 INFORMATIONAL/QUALITY ASSURANCE/CONTROL SUBMITTALS

- A. Field quality-control test reports.
- B. Warranties: Special warranties specified in this Section.

1.4 CLOSEOUT DOCUMENTS

- A. General: Closeout Submittals are to be submitted with O and M Manuals only. Do not submit with other ACTION and INFORMATIONAL Submittals:
 - 1. Operation and Maintenance Data: For computer-room air-conditioning units to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
- C. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- D. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- E. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 01.
- F. Units shall be designed to operate with HCFC-free refrigerants.

1.6 COORDINATION

- A. Coordinate layout and installation of computer-room air-conditioning units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of computer-room air-conditioning units that fail in materials or workmanship within specified warranty period.
- B. Warranty Period for Unit: Manufacturer's standard, but not less than five years from date of Substantial Completion.

1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fan Belts: One set for each belt-drive fan.
 2. Filters: One set of filters for each unit.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install computer-room air-conditioning units level and plumb, maintaining manufacturer's recommended clearances. Install according to ARI Guideline B.
- B. Curb Support: Install and secure roof-mounting units on curbs and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.
- C. Install suspended components level. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.
- D. Install air-cooled condenser on rubber-in-shear vibration isolators.
- E. Support suspended units from structure using threaded steel rods and elastomeric or spring hanger having 1-inch deflection. Vibration-control devices and installation requirements are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Water and Drainage Connections: Comply with applicable requirements in Division 23 Section "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.
- D. Hot-Water Heating Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Provide shutoff valves in inlet and outlet piping to reheat coils.
- E. Refrigerant Piping: Comply with applicable requirements in Division 23 Section "Refrigerant Piping." Provide shutoff valves and piping.
- F. Electrical System Connections: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.

- G. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- H. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 2. After installing computer-room air-conditioning units and after electrical circuitry has been energized, test for compliance with requirements.
 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Verify that computer-room air-conditioning units are installed and connected according to manufacturer's written instructions and the Contract Documents.
- C. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 Sections.
- D. Complete installation and startup checks according to manufacturer's written instructions.
- E. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain computer-room air-conditioning units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 81 23

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EXISTING VAV SCHEDULE HEATING COIL															
VAV No.	ROOM SERVED	COOLING CFM	HEATING CFM	EXT.S.P.	MBH	GPM	EAT	LAT	EWT	LWT	MIN ROWS	ELECTRICAL DATA	Duct Inlet Diamet er	MANUFACTURER	MODEL
VAV-A1	A108	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 12
VAV-A2	A108	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 12
VAV-A3	A104	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-A4	A109	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-A5	A103	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-A6	A107	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-A7	A102	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-A8	A111	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-A9	A101	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-A10	A112	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-A11	A119	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-A12	A115	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-A13	A114	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-A14	A113	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-A15	A121	350 CFM	250 CFM	0.5 in-wg	13.5	1.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	5"	Enviro Tec Inc.	SDR-WC - SIZE 5
VAV-A16	A107	350 CFM	250 CFM	0.5 in-wg	13.5	1.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	5"	Enviro Tec Inc.	SDR-WC - SIZE 5
VAV-A17	A107	350 CFM	250 CFM	0.5 in-wg	13.5	1.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	5"	Enviro Tec Inc.	SDR-WC - SIZE 5
VAV-B1	B116	1,200 CFM	700 CFM	0.5 in-wg	41.6	3.5 GPM	55 F	110 F	180 F	156 F	2	277 V-160 Hz	12"	Enviro Tec Inc.	SDR-WC - SIZE 12
VAV-B2	B113	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B3	B117	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B4	B112	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B5	B118	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B6	B111	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B7	B109	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B8	B110	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B9	B121	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B10	B109	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B11	B101	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B12	B102	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B13	B103	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B14	B107	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B15	B108	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-B16	B115	350 CFM	250 CFM	0.5 in-wg	13.5	1.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	5"	Enviro Tec Inc.	SDR-WC - SIZE 5
VAV-B17	B115	350 CFM	250 CFM	0.5 in-wg	13.5	1.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	5"	Enviro Tec Inc.	SDR-WC - SIZE 5
VAV-C1	C134 C135	975 CFM	600 CFM	0.5 in-wg	32.4	2.5 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-C2	C134	650 CFM	450 CFM	0.5 in-wg	24.3	2.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	8"	Enviro Tec Inc.	SDR-WC - SIZE 8
VAV-C3	C133	350 CFM	200 CFM	0.5 in-wg	10.8	1.0 GPM	55 F	105 F	180 F	158 F	2	277 V-160 Hz	5"	Enviro Tec Inc.	SDR-WC - SIZE 5
VAV-C4	C129 C138	300 CFM	175 CFM	0.5 in-wg	9.5	1.0 GPM	55 F	105 F	180 F	158 F	2	277 V-160 Hz	5"	Enviro Tec Inc.	SDR-WC - SIZE 5
VAV-C5	C124	350 CFM	200 CFM	0.5 in-wg	10.8	1.0 GPM	55 F	105 F	180 F	158 F	2	277 V-160 Hz	5"	Enviro Tec Inc.	SDR-WC - SIZE 5
VAV-C6	C126 C128	600 CFM	350 CFM	0.5 in-wg	18.9	1.5 GPM	55 F	105 F	180 F	158 F	2	277 V-160 Hz	8"	Enviro Tec Inc.	SDR-WC - SIZE 8
VAV-C7	C132	400 CFM	200 CFM	0.5 in-wg	10.8	1.0 GPM	55 F	105 F	180 F	158 F	2	277 V-160 Hz	6"	Enviro Tec Inc.	SDR-WC - SIZE 6
VAV-C8	C115 C116 C117 C121	400 CFM	350 CFM	0.5 in-wg	16.9	1.5 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	8"	Enviro Tec Inc.	SDR-WC - SIZE 8
VAV-C9	C123	450 CFM	250 CFM	0.5 in-wg	13.5	1.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	6"	Enviro Tec Inc.	SDR-WC - SIZE 6
VAV-C10	C122	350 CFM	200 CFM	0.5 in-wg	10.8	1.0 GPM	55 F	105 F	180 F	158 F	2	277 V-160 Hz	6"	Enviro Tec Inc.	SDR-WC - SIZE 6
VAV-C11	C112	350 CFM	200 CFM	0.5 in-wg	10.8	1.0 GPM	55 F	105 F	180 F	158 F	2	277 V-160 Hz	6"	Enviro Tec Inc.	SDR-WC - SIZE 6
VAV-C12	C103	150 CFM	75 CFM	0.5 in-wg	4.0	0.5 GPM	55 F	105 F	180 F	161 F	2	277 V-160 Hz	6"	Enviro Tec Inc.	SDR-WC - SIZE 5
VAV-C13	C110	350 CFM	200 CFM	0.5 in-wg	10.8	1.0 GPM	55 F	105 F	180 F	158 F	2	277 V-160 Hz	6"	Enviro Tec Inc.	SDR-WC - SIZE 6
VAV-C14	C108	350 CFM	200 CFM	0.5 in-wg	10.8	1.0 GPM	55 F	105 F	180 F	158 F	2	277 V-160 Hz	6"	Enviro Tec Inc.	SDR-WC - SIZE 6
VAV-C15	C109	175 CFM	100 CFM	0.5 in-wg	5.4	0.5 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	5"	Enviro Tec Inc.	SDR-WC - SIZE 5
VAV-C16	C106 C114	625 CFM	350 CFM	0.5 in-wg	18.9	1.5 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	8"	Enviro Tec Inc.	SDR-WC - SIZE 8
VAV-C17	C103	1,100 CFM	750 CFM	0.5 in-wg	40.5	3.0 GPM	55 F	105 F	180 F	153 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-C18	C151 C154 C155	750 CFM	450 CFM	0.5 in-wg	24.3	2.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	8"	Enviro Tec Inc.	SDR-WC - SIZE 8
VAV-C19	C149	750 CFM	450 CFM	0.5 in-wg	24.3	2.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	8"	Enviro Tec Inc.	SDR-WC - SIZE 8
VAV-C20	C141	1,500 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	14"	Enviro Tec Inc.	SDR-WC - SIZE 14
VAV-C21	C158 C159	350 CFM	225 CFM	0.5 in-wg	12.2	1.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	5"	Enviro Tec Inc.	SDR-WC - SIZE 5
VAV-C22	C157	450 CFM	275 CFM	0.5 in-wg	14.9	1.5 GPM	55 F	105 F	180 F	160 F	2	277 V-160 Hz	6"	Enviro Tec Inc.	SDR-WC - SIZE 6
VAV-C23	C160	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-C24	C161	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-C25	C162	900 CFM	650 CFM	0.5 in-wg	35.1	3.0 GPM	55 F	105 F	180 F	157 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-C26	C139	1,500 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	14"	Enviro Tec Inc.	SDR-WC - SIZE 14
VAV-C27	C163	900 CFM	650 CFM	0.5 in-wg	35.1	3.0 GPM	55 F	105 F	180 F	157 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-C28	C130 C137	750 CFM	450 CFM	0.5 in-wg	24.3	2.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	8"	Enviro Tec Inc.	SDR-WC - SIZE 8
VAV-C29	C133	350 CFM	225 CFM	0.5 in-wg	12.2	1.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	6"	Enviro Tec Inc.	SDR-WC - SIZE 6

EXISTING VAV SCHEDULE HEATING COIL															
VAV No.	ROOM SERVED	COOLING CFM	HEATING CFM	EXT.S.P.	MBH	GPM	EAT	LAT	EWT	LWT	MIN ROWS	ELECTRICAL DATA	Duct Inlet Diamet er	MANUFACTURER	MODEL
VAV-D1	D103	450 CFM	250 CFM	0.5 in-wg	13.5	1.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	8"	Enviro Tec Inc.	SDR-WC - SIZE 8
VAV-D2	D104	1,500 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	12"	Enviro Tec Inc.	SDR-WC - SIZE 12
VAV-D3	D105	500 CFM	250 CFM	0.5 in-wg	13.5	1.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	8"	Enviro Tec Inc.	SDR-WC - SIZE 8
VAV-D4	D106	1,500 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	14"	Enviro Tec Inc.	SDR-WC - SIZE 14
VAV-D5	D107	1,000 CFM	700 CFM	0.5 in-wg	37.8	3.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	10"	Enviro Tec Inc.	SDR-WC - SIZE 10
VAV-D6	D110	500 CFM	250 CFM	0.5 in-wg	13.5	1.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	8"	Enviro Tec Inc.	SDR-WC - SIZE 8
VAV-D7	D111 D112 D113	400 CFM	250 CFM	0.5 in-wg	13.5	1.0 GPM	55 F	105 F	180 F	155 F	2	277 V-160 Hz	6"	Enviro Tec Inc.	SDR-WC - SIZE 6
VAV-D8	D116 D117	250 CFM	150 CFM	0.5 in-wg	8.1	1.0 GPM	55 F	105 F	180 F	164 F	2	277 V-160 Hz	6"	Enviro Tec Inc.	SDR-WC - SIZE 6
VAV-D9	D118	500 CFM	300 CFM	0.5 in-wg	16.2	1.5 GPM	55 F	105 F	180 F	158 F	2	277 V-160 Hz	6"	Enviro Tec Inc.	SDR-WC - SIZE 6
VAV-D10	D108	750 CFM	450 CFM	0.5 in-wg	24.3	2.0 GPM	55 F	105 F							