SECTION 23 05 29

# HANGERS AND SUPPORTS FOR HVAC DUCTWORK, PIPING, AND EQUIPMENT

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. Scope:
   1. Contractor shall provide all labor, materials, tools, equipment and incidentals as shown, specified and required to furnish and install hangers and supports complete with required appurtenances for HVAC ductwork, piping, and equipment.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the installation of items that must be installed with, or before, the hangers and supports for HVAC ductwork, piping, and equipment Work.

C. Related Sections:
   1. Section 03 60 00, Grouting.
   2. Section 05 05 33, Anchor Systems.
   3. Section 05 12 00, Structural Steel Framing.
   4. Section 05 50 13, Miscellaneous Metal Fabrications.

### 1.2 REFERENCES

A. American National Standards Institute (ANSI).
   1. ANSI B1.1 – Unified Inch Screw Threads (ASME B1.1).

B. American Society of Civil Engineers (ASCE).
   1. ASCE 7 – Minimum Design Loads for Buildings and Other Structures.

C. American Society for Testing and Materials (ASTM).
   1. ASTM A36/A36M – Standard Specification for Carbon Structural Steel.
   2. ASTM A47/A47M – Standard Specification for Ferritic Malleable Iron Castings.
   3. ASTM A123/A123M – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   4. ASTM A153/A153M – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   5. ASTM A307 – Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
   6. ASTM A575 – Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.
   7. ASTM A668/A688M – Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use.

D. American Welding Society (AWS).
   1. AWS B2.1 – Specification for Welding Procedure and Performance Qualification.

E. Federal Specifications (FS).
   1. FS WW-H-171 – Hangers and Supports, Pipe.

F. Manufacturers Standardization Society (MSS).
   1. MSS SP 58 – Pipe Hangers and Supports-Materials, Design and Manufacture.
   2. MSS SP 69 – Pipe Hangers and Supports - Selection and Application.

G. National Fire Protection Association (NFPA).
   1. NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems.

H. Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
   1. HVAC Duct Construction Standards – Metal and Flexible.
   2. Seismic Restraint Manual: Guidelines for Mechanical Systems.
   3. Thermoset FRP Duct Construction Manual.

## 1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer:
      a. Minimum of five years of experience producing substantially similar equipment and able to show evidence of at least five installations in satisfactory operation for at least five years.
   2. Professional Engineer:
      a. Engage a registered professional engineer legally qualified to practice in New York State and experienced in providing engineering services of the kind indicated.
      b. Submit qualifications data.
      c. Responsibilities include but are not necessarily limited to:
         1) Carefully reviewing system performance and design criteria stated in the Contract Documents.
         2) Preparing written requests for clarifications or interpretations of performance or design criteria for submittal to Engineer by Contractor.
         3) Preparing or supervising the preparation of design calculations and related drawings, Shop Drawings, testing plan development, test-result interpretation and a comprehensive engineering analysis verifying compliance of the system with the requirements of the Contract Documents.
         4) Signing and sealing all calculations and design drawings, and Shop Drawings.
         5) Certifying that:
            a) it has performed the design of the system in accordance with the performance and design criteria stated in the Contract Documents, and

b) the said design conforms to all applicable local, state and federal codes, rules and regulations, and to the prevailing standards of practice.

3. Installer:
   a. Engage an experienced installer to perform the work of this Section who has specialized in installing hangers and supports for HVAC ductwork, piping, and equipment similar to that required for this Project and who is acceptable to manufacturer.
   b. Submit name and qualifications to Engineer along with the following information on a minimum of three successful projects:
      1) Names and telephone numbers of owners, architects or engineers responsible for projects.
      2) Approximate contract cost of the hangers and supports for HVAC ductwork, piping, and equipment.
      3) Amount of area installed.
4. Welding:
   a. Qualify processes and operators in accordance with AWS B2.1 as appropriate for material to be welded.
   b. Provide certification that operators employed on or to be employed for the Work have satisfactorily passed AWS qualification tests within previous 12 months. Ensure that all certifications are current.

B. Component Supply and Compatibility:
1. Obtain all equipment included in this Section regardless of the component manufacturer from a single hangers and supports for HVAC ductwork, piping, and equipment manufacturer.
2. Require the hangers and supports for HVAC ductwork, piping, and equipment manufacturer to review and approve or to prepare all Shop Drawings and other submittals for all components furnished under this Section.
3. All components shall be specifically constructed for the specified service conditions and shall be integrated into the overall equipment assembly by the hangers and supports for HVAC ductwork, piping, and equipment manufacturer.

C. Regulatory Requirements:
1. International Building Code (IBC).
2. National Fire Protection Association (NFPA).
3. Local and State Building Codes and Ordinances.
4. Permits: Contractor shall obtain and pay for all required permits, fees and inspections.

## 1.4 SUBMITTALS

A. Action Submittals: Submit the following:
1. Shop Drawings:
   a. Drawings showing fabrication methods, assembly, accessories, and installation details.
   b. Setting drawings, templates, and directions for the installation of anchor bolts and other anchorages.

c. Drawings showing floor supported components and installation arrangement.

2. Product Data:
   a. Manufacturer's literature, illustrations, specifications, weight, dimensions, required clearances, materials of construction, and performance data for all equipment.
   b. Complete component list.
   c. Detailed description of each component.
   d. Catalog cut sheets for each component.
   e. Deviations from Contract Documents. Any exceptions to the Contract Documents must be clearly defined. Contractor shall be responsible for any additional expenses that may occur due to any exception made.
   f. Other technical data related to specified material and equipment as requested by Engineer.
3. Delegated Design Submittals:
   a. 1/4-inch scale HVAC ductwork, piping, and equipment layouts, dimensioned to show length of runs, with all expansion joints, alignment guides, anchors and appurtenances required for proper control of HVAC ductwork, piping, and equipment forces. The drawings shall include all forces acting on the HVAC ductwork, piping, and equipment and the corresponding reactions of the compensation and anchor devices provided.
   b. All drawings, design calculations, and a letter indicating that the hanger and support systems have been properly designed shall be signed and sealed by a registered professional engineer legally qualified to practice in New York State.

B. Informational Submittals: Submit the following:
1. Certificates:
   a. Independent certification reports.
2. Manufacturer Instructions:
   a. Instructions and recommendations for handling, storing, protecting the equipment.
   b. Installation Data.
3. Source Quality Control Submittals:
   a. Factory test reports.
4. Qualifications Statements:
   a. Manufacturer, when requested by Engineer.
   b. Professional Engineer, when requested by Engineer.
   c. Installer, when requested by Engineer.
   d. Welding, when requested by Engineer.

## 1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading:
1. Deliver materials to the Site to ensure uninterrupted progress of the Work.
2. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete, in ample time to prevent delay of that Work.
3. Comply with manufacturer's recommendations for rigging of equipment.

B. Storage and Protection:
   1. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.
   2. Store all equipment in covered storage off the ground and prevent condensation and in accordance with the manufacturer's recommendations for long-term storage.

C. Acceptance at Site:
   1. All boxes, crates and packages shall be inspected by Contractor upon delivery to the Site. Contractor shall notify Engineer, in writing, if any loss or damage exists to equipment or components. Replace lost equipment or components and repair damage to new condition, in accordance with manufacturer's instructions.

## PART 2 - PRODUCTS

### 2.1 SYSTEM PERFORMANCE

A. Design Criteria:
   1. Designs generally accepted as exemplifying good engineering practice and using stock or production parts shall be utilized wherever possible.
   2. Accurate weight balance calculations shall be made to determine the required force at each hanger and support location and the weight load at each force concentration point.
   3. Hangers and supports shall be capable of supporting and restraining HVAC ductwork, piping, and equipment in all conditions of operation. They shall allow free expansion and contraction, and prevent excessive stress resulting from transferred weight being induced into the HVAC ductwork, piping, and equipment.
   4. Hangers and supports shall be designed so that they cannot become disengaged by movements of the supported HVAC ductwork, piping, and equipment.
   5. Rod length shall be limited to a maximum length of eight linear feet.
   6. HVAC ductwork, piping, and equipment that cannot be hung by rod and hanger arrangement shall be floor or wall supported.
   7. All structural components shall be designed based on static and dynamic loads imposed by the supported HVAC ductwork, piping, and equipment and shall include a safety factor of 2 for the yield strength. Minimum angle sizes shall be 2-inch x 2-inch x1/4-inch.
   8. Load ratings, materials and installation shall be consistent with the recommendations from the latest edition of MSS SP 58, MSS SP 69, and FS WW-H-171.
   9. Hanger and support design calculations for all HVAC ductwork, piping, and equipment shall be signed and sealed by a registered professional engineer legally qualified to practice in the State of New York.

## 2.2 MANUFACTURERS

A. Manufacturer: Provide product of one of the following:
   1. Erico International Corporation.
   2. Anvil International.
   3. Or equal.

## 2.3 DETAILS OF CONSTRUCTION

A. Materials:
   1. Hangers, supports, restraints, and appurtenances located in corrosive areas shall be Type 316 stainless steel.
   2. Hangers, supports, restraints, and appurtenances located in non-corrosive or dusty areas shall be hot dipped galvanized steel in accordance with ASTM A123/A123M and ASTM A153/A153M.
   3. Hangers, supports, restraints, and appurtenances located outdoors shall be Type 316 stainless steel.
   4. Steel used for the support of uninsulated copper piping or plastic piping shall be PVC coated.

B. Components of hangers and supports shall conform to the following:
   1. Bolts: ASTM A307, Grade A, unless otherwise specified below.
   2. Forgings: ASTM A668/A688M.
   3. Malleable Iron: ASTM A47/A47M.
   4. Rods and Bars: ASTM A575.
   5. Threads: Unified Screw Threads, Class 2A and 2B, ANSI B1.1.
   6. Structural Steel: ASTM A36/A36M.

C. Hanger Attachments: The following types of attachments shall be considered acceptable:
   1. Adjustable Steel Clevis: FS WW-H-171E, Type 1.
   2. Steel Double Bolt Pipe Clamp: FS WW-H-171E, Type 3.
   3. Steel Pipe Clamp: FS WW-H-171E, Type 4.
   4. Adjustable Swivel Pipe Ring: FS WW-H-171E, Type 6.
   5. Adjustable Steel Band Hanger: FS WW-H-171E, Type 7.
   6. Riser Clamp: FS WW-H-171E, Type 8.
   7. Light-Duty Clevis Hanger: FS WW-H-171E, Type 12.
   8. Long Clips: FS WW-H-171E, Type 26.
   9. Offset J-Hooks: FS WW-H-171E, Type 27.
   10. Steel Pipe Covering Protection Saddle: FS WW-H-171E, Type 40A.
   11. Insulation Protection Shield: FS WW-H-171E, Type 41.
   12. Pipe Saddle Support: FS WW-H-171E, Type 37.
   13. Pipe Stanchion Saddle: FS WW-H-171E, Type 38.
   14. Pipe Saddle Support with Base: FS WW-H-171E, Type 36.
   15. Adjustable Roller Hanger: FS WW-H-171E, Type 42.

D. Structural Attachments: The following types of attachments shall be considered acceptable:

1. Side Beam Clamp: FS WW-H-171E, Type 20.
2. Center I-Beam Clamp: FS WW-H-171E, Type 21.
3. Welded Steel Bracket: FS WW-H-171E, Types 32 and 33.
4. Side Beam Bracket: FS WW-H-171E, Type 35.

E. Hanger Rod Attachments: Use as required to complete assembly:
1. Forged Steel Clevis: FS WW-H-171E, Type 14.
2. Adjustable Turnbuckle: FS WW-H-171E, Type 15.
3. Forged Steel Welders Eye Nut: FS WW-H-171E, Type 17.

F. Concrete anchorage shall be provided in accordance with Section 05 05 33, Anchor Systems.

G. Structural steel shall be provided in accordance with Section 05 12 00, Structural Steel Framing.

H. Miscellaneous metal fabrications shall be provided in accordance with Section 05 50 13, Miscellaneous Metal Fabrications.

## 2.4 SOURCE QUALITY CONTROL

A. Shop Tests:
1. Equipment shall be completely manufactured and pre-assembled in accordance with Reference Standards. Perform the following tests and inspections at factory before shipment:
a. Tested and inspected for approval as a unit by Underwriters Laboratories Inc., UL Label or equal.
b. Factory test equipment to ensure that the entire package has been properly fabricated and assembled, that the package meets the specified performance requirements including manufacturer's data report.

# PART 3 - EXECUTION

## 3.1 INSPECTION

A. Examine conditions under which materials and equipment will be installed and notify Engineer in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

B. Take field measurements where required prior to installation to ensure proper fitting of Work.

## 3.2 INSTALLATION

A. General:
1. Install the equipment in accordance with the Contract Documents and by manufacturer's instructions and recommendations. Obtain written

interpretation from Engineer in the event of conflict between manufacturer's instructions and recommendations and the Contract Documents.
2. Install in accordance with Laws and Regulations.
3. Do not modify structures to facilitate installation of equipment, unless approved in writing by Engineer.
4. Installation to conform to requirements of all local and state codes.

B. Ductwork:
1. The construction and installation of hangers and supports for ductwork shall conform to the recommendations given in the SMACNA HVAC Duct Construction Standards except as specified.
2. Hanger rods shall have threaded ends.
3. All ductwork shall be supported from trapeze type hangers. No sheet metal duct hangers or straps will be allowed.
4. A pair of rods shall be provided at each duct support point.
5. For nonmetal ductwork, there shall be not less than a 1/4-inch buildup of FRP over the duct at each support. Each support shall be furnished with a 1/8-inch thick Teflon sheet to shield the duct from the support.

C. Piping:
1. Insulated pipes with vapor barriers shall have an insulation protection shield conforming to FS WW-H-171E, Type 41 tack-welded to hanger.
2. Insulated pipes without vapor barriers shall have a steel protection saddle conforming to FS WW-H-171E, Type 40A.
3. All uninsulated copper piping shall be supported by plastic coated steel pipe attachments.
4. All piping shall be braced as required, to prevent sway in any direction.
5. All insulated piping 3-inch diameter and larger shall be supported by roller hangers conforming to FS WW-H-171E, Type 42.
6. Additional supports shall be placed immediately adjacent to any change in direction.
7. Supports for Vertical Piping:
   a. Provide riser clamp placed under hub, fitting or coupling with approved solid bearing on steel sleeve at each floor level.
   b. Where riser clamps are used with plastic piping they shall be modified so as not to exert any compressive forces on the pipe.
   c. Support spacing shall not exceed code requirements.
8. Allow clearances for expansion and contraction of piping.

D. Anchorages and Base Plates:
1. Provide anchorages in new or existing concrete, as applicable, in accordance with equipment manufacturer's recommendations and the Contract Documents. Install anchors in accordance with Section 05 05 33, Anchor Systems.
2. Where used, pour concrete bases up to one inch below equipment baseplate or support leg as applicable. Base with equipment mounted shall then be accurately shimmed to grade and spaces between filled with non-shrink grout in accordance with Section 03 60 00, Grouting. After grout has reached its initial set, exposed edges shall be neatly cut back 1/2 inch.

## 3.3 ADJUSTING

A. Adjust all equipment for proper settings.

## 3.4 CLEANING

A. Thoroughly clean all equipment and accessories prior to installation.

B. Remove all dirt, rust, dust, etc. from equipment and accessories after installation.

C. Remove and dispose of all debris and waste from the Site resulting from installation.

## 3.5 SCHEDULES

A. Hangers and Supports for Ductwork:
   1. Spacing:
      a. Ductwork shall be supported at distances not exceeding the spacing specified below:
         1) Metal Ductwork:
            a) Maximum Spacing: 10 feet.
         2) Flexible and Other Factory-Made Ductwork (such as FRP):
            a) Maximum Spacing: In accordance with the manufacturer's installation instructions.
   2. Hanger Rod Sizes:
      a. Hanger rods shall be sized based on static and dynamic loads imposed by the supported ductwork and shall include a safety factor of 2 for the yield strength.
      b. Rod load shall not exceed rod manufacturer's recommended capacity.

B. Hangers and Supports for Piping:
   1. Spacing:
      a. Piping shall be supported at distances not exceeding the spacing specified below or in accordance with MSS SP 58:
         1) Copper Tube:
            a) Maximum Horizontal Spacing: 6 feet.
            b) Maximum Vertical Spacing: 10 feet.
         2) Copper Pipe:
            a) Maximum Horizontal Spacing: 12 feet.
            b) Maximum Vertical Spacing: 10 feet.
         3) Steel Pipe:
            a) Maximum Horizontal Spacing: 12 feet.
            b) Maximum Vertical Spacing: 15 feet.
   2. Hanger Rod Sizes:
      a. Hanger rods shall be sized based on static and dynamic loads imposed by the supported piping and shall include a safety factor of 2 for the yield strength.
      b. Rod load shall not exceed rod manufacturer's recommended capacity.

C. Hangers and Supports for HVAC Equipment:
   1. Provide spacing and hanger rod sizes in accordance with equipment manufacturer's installation instructions.

+ + END OF SECTION + +

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. Scope:
   1. Contractor shall provide all labor, materials, tools, equipment and incidentals as shown, specified, and required to perform the testing, adjusting, and balancing for HVAC as specified herein.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the installation of items that must be installed with, or before, the testing, adjusting, and balancing for HVAC Work.

C. Related Sections:
   1. Section 10 14 00, Signage.

### 1.2 REFERENCES

A. Associated Air Balance Council (AABC).
   1. AABC National Standards for Total System Balance.

B. American National Standards Institute/American Industrial Hygiene Association (ANSI/AIHA).
   1. ANSI/AIHA Z9.5 – Laboratory Ventilation.

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
   1. ASHRAE Handbook – Fundamentals.

D. National Environmental Balancing Bureau (NEBB).
   1. NEBB Procedural Standards for Testing Adjusting Balancing of Environmental Systems.

E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
   1. SMACNA HVAC Systems – Testing, Adjusting & Balancing Handbook.

### 1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Balancer:

a. Engage an experienced balancer to perform the work of this Section who has specialized in testing, adjusting, and balancing for HVAC systems similar to that required for this Project.
b. Minimum of five years of experience in testing, adjusting, and balancing substantially similar equipment and able to show evidence of at least five installations in satisfactory operation for at least five years.
c. Submit name and qualifications to Engineer along with the following information on a minimum of five successful projects:
    1) Names and telephone numbers of owners, architects or engineers responsible for projects.
    2) Approximate contract cost of the testing, adjusting, and balancing for HVAC Work.
    3) Amount of area tested, adjusted, and balanced.
    4) Biographical information on employee proposed to directly supervise the testing, adjusting, and balancing Work.

B. Regulatory Requirements:
1. Associated Air Balance Council (AABC).
2. National Electrical Code (NEC).
3. National Environmental Balancing Bureau (NEBB).
4. National Fire Protection Association (NFPA).
5. Underwriters Laboratories Inc. (UL).
6. Local and State Building Codes and Ordinances.
7. Permits: Contractor shall obtain and pay for all required permits, fees and inspections.

## 1.4 SUBMITTALS

A. Action Submittals: Submit the following:
1. Product Data:
    a. Data sheets with name of devices, manufacturer's name, model number, latest date of calibration, and correction factors for each testing, adjusting, and balancing instruments.
    b. Other technical data related to specified material and equipment as requested by Engineer.

B. Informational Submittals: Submit the following:
1. Certificates:
    a. Certification by National Environmental Balancing Bureau (NEBB), Association Air Balance Council (AABC), or equal.
2. Source Quality Control Submittals:
    a. Specimen copies of report forms for Engineer's review and approval.
        1) Forms shall be 8-1/2 by 11-inch paper for loose-leaf binding, with blanks for certification of report and listing all required testing, adjusting, and balancing requirements and ratings.

3. Field Quality Control Submittals:
    a. Written startup and field test reports presenting results of required field testing, adjusting, and balancing.
        1) Certified reports shall be in typed format on approved forms imprinted with the company's name.
        2) Reports shall include procedure outline used to test, adjust, and balance the systems and the types of instruments used.
        3) Minimum three certified copies of testing, adjusting, and balancing reports to the Engineer for review.
        4) Reports must be submitted to Engineer and Owner for approval prior to Owner's acceptance for responsibility.
4. Qualifications Statements:
    a. Balancer, when requested by Engineer.

C. Closeout Submittals: Submit the following:
1. Maintenance Contracts:
    a. Maintenance and Repair:
        1) Provide all labor, tools, and equipment to provide a Preventive Maintenance Program and make repairs for all equipment and controls during the One Year Correction Period after the Final Acceptance by Owner. Contractor shall provide the following services for the same period of one year:
            a) Receive calls for all problems and take steps to immediately correct deficiencies, which may exist.
            b) Provide a monthly inspection of all equipment, and record the findings on a checklist hereinafter specified.
            c) Provide a Preventive Maintenance Schedule for the principle items of equipment.
            d) Respond to Owner and make repairs for all equipment and controls within 24-hours of notification by Owner.
    b. Check List:
        1) Provide a checklist and post a copy of it, where directed by the Owner.
        2) Include each piece of equipment specified or shown.
        3) Provide four columns for required quarterly inspections.
        4) Provide columns for the following:
            a) Equipment condition.
            b) Equipment operation.
            c) Equipment lubrication.
            d) Preventive maintenance.
        5) Preventive maintenance shall be performed in accordance with the manufacturer's recommendations and accepted practice.
2. Operations and Maintenance Data:

a. Submit complete Installation, Operation and Maintenance Manuals, including, test reports, maintenance data and schedules, description of operation, and spare parts information.
b. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01 78 23, Operations and Maintenance Data.

## 1.5 SITE CONDITIONS

A. Environmental Requirements:
1. Testing, adjusting, and balancing for HVAC shall be performed when outside ambient conditions are approximate to the local ASHRAE Handbook – Fundamentals design conditions for all heating and cooling functions.

# PART 2 - PRODUCTS

## 2.1 EQUIPMENT PERFORMANCE

A. Equipment Description:
1. Air Balance Instruments:
a. Provide all velometers, anemometers, pitot tubes, differential air pressure gages, manometers, hook gages, static pressure probe units, and all other instruments and accessories as required to perform all air balance tests of HVAC equipment, ducts, registers, grilles, etc.
b. Flow-measuring hoods (manufactured, not fabricated) shall be acceptable for measurement of ceiling diffuser performance only.
2. System Performance Measuring Instruments:
a. Provide insertion thermometers, sling psychrometers, tachometers, revolution counters, clamp-on volt-ammeter recorders, and other instruments as required to measure all facets of the complete HVAC system performance.

B. Performance Criteria:
1. Instrumentation shall be in accordance with NEBB, AABC, or SMACNA requirements and shall be calibrated to the accuracy standards demanded by these organizations.

## 2.2 ACCESSORIES

A. Balancing Sheaves and Belts:
1. Balancing sheaves and belts shall be provided for all belt driven equipment.
2. Sheaves and belts shall be provided to match construction and duty provided by the equipment manufacturer.
3. Equipment sheaves and belts replaced or not required to achieve balancing shall be submitted to the Owner as spare parts.

## 2.3 IDENTIFICATION

A. All equipment and component identification, including valve tags, shall be provided in accordance with Section 10 14 00, Signage.

# PART 3 - EXECUTION

## 3.1 INSPECTION

A. Heating, ventilating and air conditioning equipment and components shall be completely installed and in continuous operation, as required, to accomplish the testing, adjusting and balancing Work specified.

B. Inspect all HVAC equipment and components for proper operation prior to testing, adjusting and balancing.
   1. Fan Belt Deflection: Not less than 1/4-inch or more than 1/2-inch.

C. Pre-Startup Inspection:
   1. Verify proper equipment mounting and setting.
   2. Verify that control, interlock and power wiring is complete.
   3. Verify alignment of motors and drives.
   4. Verify proper piping connections and accessories.
   5. Verify that lubrication is completed.

D. First Run Observations:
   1. Verify direction of rotation.
   2. Verify setting of safety controls.
   3. Monitor heat build-up in bearings.
   4. Check motor loads against nameplate data.

E. Equipment Check:
   1. Verify proper overload heater sizes.
   2. Verify function of safety and operating controls.
   3. Verify proper operation of equipment.
   4. Report on inspection, observation and checking procedures.

F. Promptly report defects which may affect the Work to Engineer.

G. Should corrective measures caused by faulty installation require re-testing, adjusting and balancing, such Work shall be at no additional cost to the Owner.

## 3.2 APPLICATION

A. General:

1. Test, adjust, and balance all systems, ductwork, piping, etc. and their control systems in accordance with the AABC National Standards for Total System Balance, NEBB Procedural Standards for Testing Adjusting Balancing of Environmental Systems, SMACNA HVAC Systems - Testing, Adjusting & Balancing Handbook, or in compliance with the standard procedure manual published by the testing, adjusting, and balancing organization affiliated with Contractor. Contractor shall submit one copy of the standard procedure manual to the Engineer for their records.
2. Contractor shall provide all necessary instruments, tools, ladders, etc. to complete all testing, adjusting, and balancing Work.
3. Contractor shall assume full responsibility for safe keeping of all instruments, tools, ladders, etc. during the course of the Work.
4. Contractor shall be solely responsible for the protection and safeguarding of the Work and shall provide every protection against accidents, injury, and damage to persons and property.
5. Contractor shall keep dust, dirt, and debris to an absolute minimum and reinstall all removed ceiling components to their original positions at the end of each day's Work.
6. Contractor shall be fully responsible for removal and reinstallation of ceiling system and replacement of any component damaged.
7. Contractor shall install additional access panels at no extra cost to the Owner, as is required to gain access to equipment concealed above ceilings, behind walls, or any other concealed space.
8. Systems shall be tested, adjusted, and balanced with clean filters and strainers.
9. Where equipment is provided with a variable speed controller (VSC) or variable frequency drive (VFD), balance the equipment first with the VSC or VFD and then with balancing dampers (air systems) or valves (hydronic systems). All systems shall be optimized through the VSC or VFD by balancing with the minimum static pressure needed to meet design flow conditions.

B. Air Systems:
   1. Preliminary:
      a. Identify and list size, type and manufacturer of all equipment to be tested, including air terminals.
   2. Central Systems:
      a. Test rpm for all equipment, including adjusting of each fan, air handling unit, and air conditioning unit to design requirements within the limits of mechanical equipment provided.
      b. Test and record motor voltages and running amperes including motor nameplate data, and starter heater ratings for each unit as listed above.
      c. Make pitot tube traverse of main supply, exhaust and return ducts, determine airflow at all fans and units and adjust fans and units to within five percent of design requirements.

d. Test and record system static pressure, suction and discharge.
e. Test and adjust system for design outside air, (cfm).
f. Test and adjust system for design recirculated air, (cfm).
g. Test and record heating apparatus entering air temperatures, (dry bulb).
h. Test and record cooling apparatus entering air temperatures, (dry bulb and wet bulb).
i. Test and record heating apparatus leaving air temperatures, (dry bulb).
j. Test and record cooling apparatus leaving air temperatures, (dry bulb and wet bulb).
k. Record all fan and air handling unit speeds.
l. Record air quantity delivered by each fan and air-handling unit.

3. Distribution:
   a. Sheave and belt replacement shall be provided as the first means of accomplishing the balancing Work before volume dampers are adjusted from their initial open positions.
   b. Adjust volume dampers, control dampers, splitter dampers, etc., to proper design airflow in main ducts, branch ducts, and zones.
4. Air Terminals:
   a. Identify each air terminal as to location and determine required flow reading.
   b. Test and adjust each air terminal to within tolerance of design requirements as listed below.
      1) Positive Zones:
         a) Diffusers and Supply Air Terminals: 0 percent to +10 percent.
         b) Exhaust and Return Air Terminals: 0 percent to -10 percent.
      2) Negative Zones:
         a) Diffusers and Supply Air Terminals: 0 percent to -10 percent.
         b) Exhaust and Return Air Terminals: 0 percent to +10 percent.
      3) Neutral Zones:
         a) All Air Terminals: -10 percent to +10 percent.
   c. Test procedure on air terminals shall include recording comparison of required airflow and observed airflow, adjustment of terminal, and recording of final airflow.
   d. Adjust flow patterns from air terminal units to minimize drafts to the extent that the design and equipment permits.
5. Verification:
   a. Prepare summation of readings of observed airflow for each system, compare with required airflow, and verify that duct losses are within specified allowable range.
   b. Verify design airflow at fans as described above.
   c. If determined that the air system has not been properly balanced, Contractor shall rebalance and recheck all equipment and components in the presence of the Engineer and as accepted by the Engineer.

3.3 SCHEDULES

A. Test, adjust, and balance all HVAC equipment.

++ END OF SECTION ++

SECTION 23 31 13

METAL DUCTWORK

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. Scope:
   1. Contractor shall provide all labor, materials, tools, equipment and incidentals as shown, specified and required to furnish and install metal ductwork complete and operational with accessories.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the installation of items that must be installed with, or before, the metal ductwork Work.

C. Related Sections:
   1. Section 10 14 00, Signage.
   2. Section 23 05 29, Hangers and Supports for HVAC Ductwork, Piping, and Equipment.
   3. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

### 1.2 REFERENCES

A. Air Movement and Control Association International, Inc. (AMCA).
   1. AMCA Standard 500-D – Laboratory Methods of Testing Dampers for Rating.
   2. AMCA Publication 511 – Certified Ratings Program - Product Rating Manual for Air Control Devices.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
   1. ASHRAE Standard 52.2 – Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

C. American Society for Testing and Materials (ASTM).
   1. ASTM E84 – Standard Test Method for Burning Characteristics of Building Materials.
   2. ASTM B209 – Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   3. ASTM A653/A653M – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

D. American Welding Society (AWS).
   1. AWS B2.1 – Specification for Welding Procedure and Performance Qualification.

E. National Bureau of Standard's Voluntary Product Standard.
   1. NBS PS 15-69 – Standard for Contact-Molded Reinforced Polyester Chemical Resistant Process Equipment.

F. National Fire Protection Association (NFPA).
   1. NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems.
   2. NFPA 90B – Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
   3. NFPA 701 – Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.

G. Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
   1. Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems.
   2. HVAC Duct Construction Standards – Metal and Flexible.
   3. Round Industrial Duct Construction Standards.
   4. Rectangular Industrial Duct Construction Standards.

H. Underwriters Laboratories Inc. (UL).
   1. UL 181 – Factory-Made Air Ducts and Air Connectors.
   2. UL 181A – Closure Systems for Use With Rigid Air Ducts.
   3. UL 181B – Closure Systems for Use With Flexible Air Ducts and Air Connectors.
   4. UL 555 – Fire Dampers.
   5. UL 555S – Smoke Dampers.
   6. UL 900 – Air Filter Units.

## 1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer:
      a. Minimum of five years of experience producing substantially similar equipment and able to show evidence of at least five installations in satisfactory operation for at least five years.
   2. Installer:
      a. Engage an experienced installer to perform the work of this Section who has specialized in installing metal ductwork similar to that required for this Project and who is acceptable to manufacturer.
      b. Submit name and qualifications to Engineer along with the following information on a minimum of three successful projects:
         1) Names and telephone numbers of owners, architects or engineers responsible for projects.
         2) Approximate contract cost of the metal ductwork.
         3) Amount of area installed.
   3. Welding:
      a. Qualify processes and operators in accordance with AWS B2.1 as appropriate for material to be welded.

b. Provide certification that operators employed on or to be employed for the Work have satisfactorily passed AWS qualification tests within previous 12 months. Ensure that all certifications are current.

B. Regulatory Requirements:
1. National Electrical Code (NEC).
2. National Fire Protection Association (NFPA).
3. Underwriters Laboratories Inc. (UL).
4. Local and State Building Codes and Ordinances.
5. Permits: Contractor shall obtain and pay for all required permits, fees and inspections.

## 1.4 SUBMITTALS

A. Action Submittals: Submit the following:
1. Shop Drawings:
a. Drawings showing fabrication methods, assembly, accessories, and installation details.
b. 1/4-inch scale duct layouts, dimensioned to show length of runs, sizes, support spacing and expansion provisions.
c. Detailed installation drawing of each individual component showing:
1) Mounting requirements.
2) Locations.
d. Setting drawings, templates, and directions for the installation of anchor bolts and other anchorages.
2. Product Data:
a. Manufacturer's literature, illustrations, specifications, weight, wall thicknesses, design pressures, dimensions, required clearances, materials of construction, and performance data for all equipment.
b. Complete component list.
c. Detailed description of each component.
d. Catalog cut sheets for each component.
e. Deviations from Contract Documents. Any exceptions to the Contract Documents must be clearly defined. Contractor shall be responsible for any additional expenses that may occur due to any exception made.
f. Other technical data related to specified material and equipment as requested by Engineer.

B. Informational Submittals: Submit the following:
1. Certificates:
a. Certification that all stainless steel ductwork, accessories, and hardware are of the Type specified.
2. Manufacturer Instructions:
a. Instructions and recommendations for handling, storing, protecting the equipment.
b. Installation Data.
3. Source Quality Control Submittals:
a. Factory test reports.
4. Field Quality Control Submittals:

a. Written report presenting results of required field testing.

5. Supplier Reports:
   a. Submit written report of results of each visit to Site by Supplier's service personnel, including purpose and time of visit, tasks performed, and results obtained. Submit within two days of completion of visit to the Site.
6. Qualifications Statements:
   a. Manufacturer, when requested by Engineer.
   b. Installer, when requested by Engineer.
   c. Welding, when requested by Engineer.

C. Closeout Submittals: Submit the following:
1. Record Documentation:
   a. During progress of the Work keep an up-to-date set of the Drawings showing field and Shop Drawing modifications. Immediately upon completion of the Work, submit "pdf" of CADD drawings showing the actual in place installation of all ductwork and equipment installed under this Section at a scale satisfactory to the Owner. The drawings shall show all ductwork on plans and in sections, with all reference dimensions and elevations required for complete Record Drawings of the systems. Two paper prints shall also be furnished. The prints and electronic copies of the CADD files shall be furnished no later than 30 days after completion of the Contract and prior to final payment.

## 1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading:
1. Deliver materials to the Site to ensure uninterrupted progress of the Work.
2. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete, in ample time to prevent delay of that Work.
3. Comply with manufacturer's recommendations for rigging of equipment.

B. Storage and Protection:
1. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.
2. Store all equipment in covered storage off the ground and prevent condensation and in accordance with the manufacturer's recommendations for long-term storage.

C. Acceptance at Site:
1. All boxes, crates and packages shall be inspected by Contractor upon delivery to the Site. Contractor shall notify Engineer, in writing, if any loss or damage exists to equipment or components. Replace lost equipment or components and repair damage to new condition, in accordance with manufacturer's instructions.

## 1.6 SITE CONDITIONS

A. Existing Conditions:
   1. The Contract Documents show the general arrangement and extent of the Work to be done. The exact location and arrangement of all parts shall be determined as the Work progresses. The exact location of all parts of the Work is governed by the general building plans and the actual building conditions.
   2. The Drawings are intended as an indication of the arrangement of equipment and ductwork and are as nearly correct as can be determined in advance of the actual construction of the Work. Equipment, ductwork, and appurtenances found to interfere with the construction of the building, plumbing apparatus and piping, electrical wiring or other obstructions, etc., must be changed in location to clear such obstructions.

# PART 2 - PRODUCTS

## 2.1 SYSTEM PERFORMANCE

A. System Description:
   1. The Drawings show the general arrangement of all systems. Should local conditions necessitate rearrangement of the systems, Contractor, before proceeding with the Work, shall prepare and submit complete drawings showing all details of the proposed rearrangement for written approval.
   2. The connections shown to the various units are intended as an indication only. The actual connections at the time of installation to be made and arranged to suit the requirements of each case and adequately provide for expansion and minimize the amount of space required for the same.
   3. The Drawings do not show all offsets, fittings, accessories and details, which may be required. Contractor shall carefully examine all of the General Construction, Electrical, Mechanical, Structural and other Drawings and the respective Specifications for conditions which may affect the installation of the Work, and shall arrange the Work accordingly, furnishing all required items to meet such conditions which are not specified as work “by others,” to complete the systems to the true extent of the Contract Documents.

B. Design Criteria:
   1. All sheet metal construction shall be in accordance with the construction details and installation details in the latest edition of the SMACNA HVAC Duct Construction Standards. This Standard is hereinafter referred to as HVAC DS.
   2. Sheet metal construction shall conform to the following minimum pressure classification (positive and negative pressure), unless otherwise shown or specified:

      a. Ductwork serving process spaces: 2-inch W.G.

## 2.2 DETAILS OF MATERIALS

A. Material Type:
   1. Aluminum ductwork shall be Alloy 3003 – H-14 in accordance with ASTM B209.
      a. All accessories for aluminum ductwork shall be aluminum, unless noted otherwise.
   2. Stainless steel ductwork shall be Type 316.
      a. All accessories for stainless steel ductwork shall be Type 316 stainless steel, unless noted otherwise.
      b. Welded stainless steel ductwork shall be Type 316L.

B. Duct construction alternatives (duct gauge in relation to reinforcement spacing) selected by Contractor from HVAC DS Tables shall be identified by duct system and shall be submitted in schedule form to the Engineer prior to beginning installation of ductwork. Contractor shall construct ductwork to meet the requirements of the HVAC DS Tables in conjunction with the minimum duct thickness schedules in Article 3.10 below.

C. Thickness of aluminum ductwork and size and thickness of aluminum supports shall be appropriately converted using the aluminum conversion tables in the HVAC DS.

D. Rectangular ductwork longitudinal seams shall be Pittsburgh Lock type with permanently elastomeric sealant applied continuously within the seam.

E. Round ductwork seams shall be spiral lock seam except for laboratory exhaust systems which shall be solid wall welded longitudinal seams.

F. Duct reinforcement shall be made using external stiffener angles. Tie rods shall not be acceptable. Stiffener angles shall be constructed of the same material as the ductwork.

G. Transverse Joints:
   1. Manufacturer: Provide product of one of the following:
      a. Ductmate Industries, Inc.
      b. Elgen Manufacturing Company, Inc.
      c. Or equal.
   2. Ductwork shall be connected by a mechanical joining system, except where otherwise noted.
   3. Manufacturer's installation instructions will be followed, except where otherwise noted.
   4. SMACNA T-24 and other flange type connectors formed from the duct edge will NOT be allowed.
   5. All connectors shall meet or exceed the functional criteria outlined in the HVAC DS and shall be constructed of the same material as the ductwork.

H. Turning Vanes:
   1. Manufacturer: Provide product of one of the following:

a. Ductmate Industries, Inc.
b. Elgen Manufacturing Company, Inc.
c. C.L. Ward & Family, Inc.
d. Or equal.

2. Material: Same material as ductwork.
3. Ducts 24-inches or shorter:
   a. Vanes: Single thickness.
   b. Runners: Type 2.
4. Ducts taller than 24-inches:
   a. Vanes: Double thickness.
   b. Runners: Type 1.

I. Splitter Dampers:
1. Reference: HVAC DS.
2. Material: Same material as ductwork.

J. Transitions and Offsets:
1. Reference: HVAC DS.
2. Material: Same material as ductwork.

K. Branch Take-Offs:
1. Reference: HVAC DS.
2. Material: Same material as ductwork.
3. 45 degrees, NO straight taps, unless specifically shown.

L. Rectangular Square Throat Elbows:
1. Reference: HVAC DS.
2. Material: Same material as ductwork.
3. Provided with turning vanes.

M. Rectangular Radius Elbows and Round Elbows:
1. Reference: HVAC DS.
2. Material: Same material as ductwork.
3. Centerline Radius: R=1.5W, unless specifically shown otherwise.

N. Round Converging Flow Fittings:
1. Converging flow fittings shall be constructed with a radius entrance to all branch taps and with no excess material projecting from the body into the branch tap entrance.
2. Branch entrances shall be by means of factory-fabricated fittings or factory fabricated duct tap assemblies.

O. Seal Class:
1. Class A – Ductwork constructed with a minimum pressure classification (positive and negative pressure) of 4-inch W.G. and up.
2. Class B – Ductwork constructed with a minimum pressure classification (positive and negative pressure) less than 4-inch W.G.

P. Leakage:
   1. Zero percent – Laboratory exhaust systems.
   2. Not to exceed five percent – All other systems.

Q. Flexible duct or duct constructed of fiberglass duct board shall not be permitted, except where specifically shown or indicated.

## 2.3 ACCESSORIES

A. Hangers and Supports:
   1. Hangers and supports shall be provided in accordance with Section 23 05 29, Hangers and Supports for HVAC Ductwork, Piping, and Equipment.

B. Motorized Control Dampers and Volume Dampers (for Rectangular Ductwork):
   1. Commercial Type Dampers for Aluminum Ductwork:
      a. Design and Performance Criteria (based on 48-inch damper width):
         1) Dampers shall be performance rated and certified in accordance with AMCA Standard 500-D and AMCA Publication 511.
         2) Maximum Design Total Static Pressure: 5.2-inch W.G.
         3) Damper Leakage: Class 1 Leakage Rated – Not more than 8 cfm per square foot at 4-inch W.G. with blade seals.
         4) Certification: Manufacturer shall submit certified test data.
      b. Product and Manufacturer: Provide one of the following:
         1) Model CD50, as manufactured by Ruskin.
         2) Model VCD-40, as manufactured by Greenheck Fan Corporation.
         3) Or equal.
      c. Details of Construction:
         1) Material: 6063-T5 aluminum.
         2) Frame: 0.125-inch thick hat channel with mounting flanges.
         3) Single Section Sizes:
            a) Minimum: 6-inch wide by 9-inch high.
            b) Maximum: 60-inch wide by 72-inch high.
         4) Blades:
            a) 6-inch wide.
            b) Opposed blades.
            c) Airfoil shape with heavy gauge 6063-T5 aluminum double skin construction.
            d) EPDM edge seals for motorized control dampers only.
         5) Linkage: Concealed in frame outside the air stream.
         6) Axles: 1/2-inch plated steel hex.
         7) Bearings: Molded synthetic.
         8) Jamb Seals: Flexible metal compressible type.
         9) Provide Type 304 stainless steel outside handle, quadrant with 2-inch standoff and approved position indicator with locking device for all volume dampers.
   2. Commercial/Industrial Type Dampers for all Metal Ductwork:
      a. Design and Performance Criteria (based on 48-inch damper width):

1) Dampers shall be performance rated and certified in accordance with AMCA Standard 500-D and AMCA Publication 511.
2) Maximum Design Total Static Pressure: 17.0-inch W.G.
3) Damper Leakage: Class 1 Leakage Rated – Not more than 8 cfm per square foot at 4-inch W.G. with blade seals.
4) Certification: Manufacturer shall submit certified test data.

b. Product and Manufacturer: Provide one of the following:
1) Model CD80AF2, as manufactured by Ruskin.
2) Model HCD-330, as manufactured by Greenheck Fan Corporation.
3) Or equal.

c. Details of Construction:
1) Material: Same as ductwork.
2) Frame: Minimum 14 gauge channel frame with mounting flanges.
3) Single Section Sizes:
a) Minimum: 6-inch wide by 12-inch high.
b) Maximum: 60-inch wide by 96-inch high.
4) Blades:
a) 6-inch wide.
b) Opposed blades.
c) Minimum 16 gauge double skin airfoil shape construction with material same as ductwork.
d) EPDM edge seals for motorized control dampers only.
5) Linkage: Concealed in frame outside the air stream.
6) Axles: Minimum 3/4-inch with material same as ductwork.
7) Bearings: Stainless steel sleeve.
8) Jamb Seals: Stainless steel compressible type.
9) Provide outside handle, quadrant with 2-inch standoff and approved position indicator with locking device constructed from same material as ductwork for all volume dampers.

C. Motorized Control Dampers and Volume Dampers (for Round Ductwork):
1. Commercial Type Dampers for all Metal Ductwork:
a. Design and Performance Criteria (based on 48-inch damper diameter):
1) Dampers shall be performance rated and certified in accordance with AMCA Standard 500-D and AMCA Publication 511.
2) Maximum Design Total Static Pressure: 4.0-inch W.G.
3) Damper Leakage: Not more than 11.30 cfm total at 1-inch W.G. with blade seals.
4) Certification: Manufacturer shall submit certified test data.

b. Product and Manufacturer: Provide one of the following:
1) Model CDRS82, as manufactured by Ruskin.
2) Or equal.

c. Details of Construction:
1) Material: Same as ductwork.
2) Frame: Minimum 16 gauge frame with 12 gauge mounting flanges.
3) Single Section Sizes:
a) Minimum: 4-inch diameter.
b) Maximum: 48-inch diameter.

4) Blades:
   a) Minimum 16 gauge double skin construction with material same as ductwork.
   b) EPDM continuous edge seals with pin angle stops for motorized control dampers only.
5) Axles: Minimum 1/2-inch with material same as ductwork.
6) Bearings: Stainless steel sleeve.
7) Provide outside handle, quadrant with 2-inch standoff and approved position indicator with locking device constructed from same material as ductwork for all volume dampers.

D. Access Doors:
1. Provide access doors for all fire and smoke dampers, control dampers, and other duct mounted devices where required to be accessible.
2. Access doors for fire and smoke dampers shall not affect the integrity of fire-resistance-rated assemblies. The access openings shall not reduce the fire-resistance rating of the assembly.
3. Access doors for fire and smoke dampers shall be labeled "FIRE/SMOKE DAMPER ACCESS", "SMOKE DAMPER ACCESS", or "FIRE DAMPER ACCESS" with minimum 1/2-inch high letters.
4. Reference: HVAC DS.
5. Material: Same as ductwork.
6. For Rectangular Ductwork:
   a. Type: Gasketed cam lock covers.
   b. Unless otherwise specified rectangular access doors shall be:
      1) 12 by X-2-inches for ducts X-inches and smaller less than 14-inches.
      2) 24 by 12-inches for ducts between 14 and 36-inches.
      3) 24 by 24-inches for ducts between 36 and 60-inches.
      4) Two 24 by 24-inch doors for ducts larger than 61-inches.
7. For Round Ductwork:
   a. Type: Industrial oval gasketed access door with locking hand wheels.
   b. Unless otherwise specified oval access door sizes shall be:

| Duct Diameter: | Nominal Opening: |
|---|---|
| 8 thru 18-inches: | 10 by 6-inches. |
| 19 thru 48-inches: | 16 by 12-inches. |
| 49 thru 72-inches: | 24 by 18-inches. |

E. Flexible Connectors (FC):
1. Design and Performance Criteria:
   a. Flexible connectors shall be tested in accordance with UL 181.
   b. Flexible connectors shall be listed and labeled as Class 0 or Class 1 flexible connectors.
   c. Flexible connectors shall meet NFPA 90A, NFPA 90B, NFPA 701, and local building codes.
   d. Maximum Design Total Static Pressure: 10.0-inch W.G.
   e. Temperature Range: -65 degrees F to 500 degrees F.
   f. Width: Minimum 4 inches, but shall not exceed 14 inches.
2. Product and Manufacturer: Provide one of the following:

a. Model Thermafab, as manufactured by Duro Dyne Corporation.
b. Model PROflex, as manufactured by Ductmate Industries, Inc.
c. Or equal.

3. Details of Construction:
   a. Base Fabric: Woven fiberglass.
   b. Coating: Silicone rubber.
   c. Weight: 17 ounce per square yard.
   d. Tensile Strength: 200 lb by 250 lb.
   e. Tear Strength: 50 lb by 40 lb.
   f. Features:
      1) Excellent high temp resistance.
      2) Excellent low temp resistance.
      3) Excellent chemical resistance.
      4) Excellent low smoke emission.
      5) Excellent ozone resistance.
      6) Excellent weathering.
      7) Unaffected by mildew.
   g. Metal connectors shall be of the same material and gauge as ductwork with double-lock fold.

F. Miscellaneous Duct Fittings:
   1. Reference: HVAC DS.
   2. Material: Same material as ductwork.

G. Sleeves:
   1. Material: Same material as ductwork passing through opening.
   2. Thickness: Minimum 24-gauge.
   3. Calk airtight with fire resistant sealant between sleeve and ductwork.

H. Duct Gaskets:
   1. Product and Manufacturer: Provide one of the following:
      a. Model 440 Gasket Tape, as manufactured by Ductmate Industries, Inc.
      b. Model 440 Butyl Gasket, as manufactured by Elgen Manufacturing Company, Inc.
      c. Or equal.
   2. Material: Non-hardening butyl.
   3. Service Temperatures: -30 degrees F to 180 degrees F.
   4. Service Life: 20 years minimum.
   5. Gaskets shall have the following Fire Hazard Classifications in accordance with ASTM E84:
      a. Flame Spread: 10 maximum.
      b. Smoke Developed: 10 maximum.

I. Hardware and Fasteners:
   1. All hardware and fasteners for aluminum and stainless steel ductwork shall be Type 316 stainless steel, unless noted otherwise.
   2. All hardware and fasteners for galvanized ductwork shall be G90 hot dipped galvanized steel, unless noted otherwise.

J. Grilles and Diffusers:
   1. General:
      a. Grilles and diffusers mounted in hung ceilings shall have a baked enamel white finish.
      b. Aluminum grilles and diffusers not mounted in hung ceilings shall have a clear anodized finish.
      c. Stainless steel grilles and diffusers shall have a satin polish [mill] finish except where white polyvinylidene fluoride (PVDF) coating is specified on the Equipment Schedule.
      d. Where registers are shown to be provided in lieu of grilles, include an integral opposed blade damper of the same construction as the grille.
   2. Supply Grilles (SG):
      a. Product and Manufacturer: Provide one of the following:
         1) Aluminum construction:
            a) Model X20, as manufactured by Anemostat.
            b) Model A54, as manufactured by Tuttle & Bailey.
            c) Model 300FL, as manufactured by Titus.
            d) Or equal.
         2) Type 316 stainless steel construction:
            a) Model SS2, as manufactured by Anemostat.
            b) Model T54SS, as manufactured by Tuttle & Bailey.
            c) Model 300RL-SS, as manufactured by Titus.
            d) Or equal.
      b. Double deflection with horizontal face bars for horizontal duct and vertical face bars for vertical duct.
      c. 3/4-inch blade spacing.
      d. For surface mounting as shown or indicated on Drawings.
   3. Return/Exhaust Grilles (RG/EG):
      a. Product and Manufacturer: Provide one of the following:
         1) Aluminum construction:
            a) Model X30, as manufactured by Anemostat.
            b) Model A70, as manufactured by Tuttle & Bailey.
            c) Model FL, as manufactured by Titus.
            d) Or equal.
         2) Type 316 stainless steel construction:
            a) Model SS3, as manufactured by Anemostat.
            b) Model T70SS, as manufactured by Tuttle & Bailey.
            c) Model RL-SS, as manufactured by Titus.
            d) Or equal.
      b. Single 0- or 45-degree deflection with horizontal face bars for horizontal duct and vertical face bars for vertical duct.
      c. 3/4-inch blade spacing.
      d. For surface mounting as shown or indicated on Drawings.

K. Wire Mesh Screens:
   1. Wire mesh screens shall be provided where shown or specified on the Drawings.

2. Material:
   a. Type 304 stainless steel mesh and frame for aluminum ductwork.
   b. Type 316 stainless steel mesh and frame for stainless steel ductwork.
3. Mesh Size: 3/4-inch by 3/4-inch interwoven with 0.135-inch (10 gauge) diameter wire.

## 2.4 IDENTIFICATION

A. All equipment and component identification shall be provided in accordance with Section 10 14 00, Signage.

## 2.5 SOURCE QUALITY CONTROL

A. Shop Tests:
   1. Equipment shall be completely manufactured and pre-assembled in accordance with Reference Standards. Perform the following tests and inspections at factory before shipment:
      a. Tested and inspected for approval as a unit by Underwriters Laboratories Inc., UL Label or equal.
      b. Factory test equipment to ensure that the entire package has been properly fabricated and assembled, that all the controls function as specified herein and that the package meets the specified performance requirements including manufacturer's data report.

# PART 3 - EXECUTION

## 3.1 INSPECTION

A. Examine conditions under which materials and equipment will be installed and notify Engineer in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

B. Take field measurements where required prior to installation to ensure proper fitting of Work.

## 3.2 PREPARATION

A. Protection of Surrounding Areas/Surfaces:
   1. Openings and penetrations shall be capped to protect the building from outside conditions.
   2. Properly cap the open ends of all ductwork at the end of each day's Work or other stopping point throughout the construction. Equipment shall be tightly covered and protected against dirt, water, and chemical or mechanical damage.

## 3.3 INSTALLATION

A. General:
   1. Install the equipment in accordance with the Contract Documents and by manufacturer's instructions and recommendations. Obtain written interpretation from Engineer in the event of conflict between manufacturer's instructions and recommendations and the Contract Documents.
   2. Install in accordance with Laws and Regulations.
   3. Do not modify structures to facilitate installation of equipment, unless approved in writing by Engineer.
   4. Installation to conform to requirements of all local and state codes.

B. All ductwork shall conform accurately to the dimensions shown, the ducts shall be straight and smooth inside with joints neatly finished. Ductwork shall be installed so as to preclude the possibility of vibration under all operating conditions.

C. Tape and seal all joints in accordance with HVAC DS. Tape shall not be used as the primary means of sealing. Tape used in sealing metallic ductwork shall be listed and labeled in accordance with UL 181A and shall be marked "181 A-P" for pressure-sensitive tape, "181 A-M" for mastic or "181 A-H" for heat-sensitive tape. Tape used in sealing flexible ductwork and connectors shall be listed and labeled in accordance with UL 181B and shall be marked "181 B-FX" for pressure-sensitive tape or "181 B-M" for mastic.

D. Fire dampers shall be provided and installed where indicated and where required by UL and authorities having jurisdiction, and shall be approved by local building codes and in accordance with the requirements of the NFPA.

E. Install all ductwork and accessories to provide a system free from buckling, warping, bellowing, or vibration.

F. All ducts at flexible connections with fans shall be supported at free end within 12-inches of flexible connection.

G. Provisions shall be made for supporting all ductwork, dampers, and other ductwork accessories, where necessary.

H. Coordinate all air outlets for compatibility with ceiling system.

## 3.4 FIELD QUALITY CONTROL

A. Manufacturer's Services:
   1. Provide a qualified, factory-trained service person to perform the following:
      a. Instruct Contractor in installing equipment.
      b. After installation, inspect and adjust equipment, verify proper operation, and assist with field testing.
      c. Instruct operations and maintenance personnel in operation and maintenance of the equipment.
   2. Manufacturer's service person shall make visits to the Site as follows:

a. First visit shall be for instructing Contractor in proper equipment installation, and assisting in installing equipment. Minimum number of hours on-Site: 8 hours.
b. Second visit shall be for checking completed installation, start-up of system; and performing field testing. Minimum number of hours on-Site: 8 hours.
c. Third visit shall be to instruct operations and maintenance personnel.
    1) Furnish services of manufacturer's qualified, factory-trained specialists to instruct operations and maintenance personnel in recommended operation and maintenance of equipment.
    2) Training requirements, duration of instruction, and qualifications shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
    3) Number of hours on-Site shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
d. Technician shall revisit the Site as often as necessary until installation is acceptable.

3. All costs, including expenses for travel, lodging, meals and incidentals, and cost of travel time, for visits to the Site shall be included in the Contract Price.

## 3.5 ADJUSTING

A. All duct systems shall be tested, adjusted, and balanced per Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

B. Test openings shall be installed in the ductwork as directed by the testing, adjusting, and balancing Contractor. Test openings shall be sealed by a screw cap and gasket.

## 3.6 CLEANING

A. Thoroughly clean all ductwork and accessories prior to installation.

B. Remove all dirt, rust, dust, etc. from ductwork and accessories after installation.

C. Remove and dispose of all debris and waste from the Site resulting from installation.

## 3.7 SCHEDULES

A. Minimum Duct Thicknesses:
    1. One gauge thicker than recommended in the HVAC DS for the same pressure classification, reinforcement and support spacing.

B. All ductwork and plenums serving the following equipment shall be stainless steel:
    1. Weaver:
        a. SF-1
        b. SF-2

C. Ductwork materials not specified above or on the Drawings shall be constructed of Type 316 SS unless otherwise directed by Engineer.

+ + END OF SECTION + +

SECTION 23 34 05

METALLIC HVAC FANS

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. Scope:
   1. Contractor shall provide all labor, materials, tools, equipment and incidentals as shown, specified and required to furnish and install metallic HVAC fans complete and operational with accessories.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the installation of items that must be installed with, or before, the metallic HVAC fans Work.

C. Related Sections:
   1. Section 10 14 00, Signage.
   2. Section 23 05 29, Hangers and Supports for HVAC Ductwork, Piping, and Equipment.
   3. Section 26 05 05, General Provisions for Electrical Systems.
   4. Section 26 05 53, Identification For Electrical Systems.
   5. Section 26 28 16.33, Disconnect Switches.
   6. Section 40 05 93, Common Motor Requirements for Process Equipment.

### 1.2 REFERENCES

A. Air Movement and Control Association International, Inc. (AMCA).
   1. AMCA Standard 99-0401 – Classification for Spark Resistant Construction.
   2. AMCA Standard 99-2408 – Operating Limits for Centrifugal Fans.
   3. AMCA Standard 204 – Balance Quality and Vibration Levels for Fans.
   4. AMCA Standard 210 – Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
   5. AMCA Standard 300 – Reverberant Room Method for Sound Testing of Fans.
   6. AMCA Standard 301 – Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

B. American Bearing Manufacturers Association (ABMA).
   1. ABMA 9 – Load Ratings and Fatigue Life for Ball Bearings.
   2. ABMA 11 – Load Ratings and Fatigue Life for Roller Bearings.

C. American Society for Testing and Materials (ASTM).
   1. ASTM B117 – Standard Practice for Operating Salt Spray (Fog) Apparatus.

D. Institute of Electrical and Electronic Engineers (IEEE).

E. National Electrical Code (NEC).

F. National Fire Protection Association (NFPA).
   1. NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems.
   2. NFPA 91 – Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.

G. Underwriters Laboratories Inc. (UL).
   1. UL 705 – Power Ventilators.

## 1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer:
      a. Minimum of five years of experience producing substantially similar equipment and able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section regardless of the component manufacturer from a single metallic HVAC fan manufacturer.
   2. Require the metallic HVAC fan manufacturer to review and approve or to prepare all Shop Drawings and other submittals for all components furnished under this Section.
   3. All components shall be specifically constructed for the specified service conditions and shall be integrated into the overall equipment assembly by the metallic HVAC fan manufacturer.

C. Regulatory Requirements:
   1. National Electrical Code (NEC).
   2. National Fire Protection Association (NFPA).
   3. Underwriters Laboratories Inc. (UL).
   4. Local and State Building Codes and Ordinances.
   5. Permits: Contractor shall obtain and pay for all required permits, fees and inspections.

D. Certifications:
   1. Metallic HVAC fans shall bear an approved label with all the necessary identification marks, electrical data, and any necessary cautions as required by the National Electric Code.
   2. Metallic HVAC fans shall be AMCA certified.

## 1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Drawings showing fabrication methods, assembly, accessories, installation details, and wiring diagrams.
      b. Setting drawings, templates, and directions for the installation of roof/equipment curbs, anchor bolts, and other anchorages.

2. Product Data:
    a. Manufacturer's literature, illustrations, specifications, weight, dimensions, required clearances, materials of construction, and performance data for all equipment.
    b. Complete component list.
    c. Detailed description of each component.
    d. Catalog cut sheets for each component.
    e. Fan performance curves with operating points.
    f. Standard and custom color selection charts for finishing system.
    g. Lubricant Specification: Furnish lubricant specification for type and grade required for equipment furnished.
    h. Deviations from Contract Documents. Any exceptions to the Contract Documents must be clearly defined. Contractor shall be responsible for any additional expenses that may occur due to any exception made.
    i. Other technical data related to specified material and equipment as requested by Engineer.
3. Testing Plans, Procedures, and Testing Limitations:
    a. Plan for performing required shop testing.
    b. Plan for performing required field testing.

B. Informational Submittals: Submit the following:
1. Certificates:
    a. Certification of painting systems, in accordance with "Finishing" Article in this Section.
    b. Independent certification reports:
        1) UL Label or equal.
        2) AMCA certification.
2. Manufacturer Instructions:
    a. Instructions and recommendations for handling, storing, protecting the equipment.
    b. Installation Data.
    c. Instructions for handling, start-up, and troubleshooting.
3. Source Quality Control Submittals:
    a. Written report presenting results of required shop testing.
    b. Factory test reports.
4. Field Quality Control Submittals:
    a. Written report presenting results of required field testing.
5. Supplier Reports:
    a. Submit written report of results of each visit to Site by Supplier's service personnel, including purpose and time of visit, tasks performed, and results obtained. Submit within two days of completion of visit to the Site.
6. Qualifications Statements:
    a. Manufacturer, when requested by Engineer.

C. Closeout Submittals: Submit the following:
1. Maintenance Contracts:

a. Service shall be provided by a factory-trained and certified equipment manufacturer's representative during the One Year Correction Period. The equipment manufacturer's representative shall maintain all equipment furnished under this Section during the first year of operation.
b. Service provided shall include the following:
1) Quarterly On-Site Service: Service intervals shall be quarterly for a minimum of one day of eight hours each quarter. The service duration shall be increased, as necessary by the equipment manufacturer's representative, taking into consideration the equipment service requirements and equipment size. Equipment manufacturer's representative shall indicate the service duration and service scope. Prior to the visits, the equipment manufacturer's representative shall contact the Owner and inquire as to problems encountered with the equipment. Service visits shall be scheduled at times agreeable to the Owner at least one week in advance. The quarterly service shall include, but not limited to the following:
a) Provide manufacturer's recommended maintenance.
b) Check all controls and components, and recalibrate or adjust as necessary.
c) Perform necessary cleaning and services that are scheduled on a quarterly basis in accordance with the approved Operations and Maintenance Manuals. Provide all expendable materials, as necessary.
d) Review and provide recommendations concerning Owner's operations.
e) Replace or repair defective controls and components.
f) Inspect control panels. Test control panel's indication lights and replace defective lights.
g) Provide a detailed field report to the Owner.
2) Technical Support: Technical support shall be provided between the hours of 8:00 AM and 4:00 PM local standard time, Monday through Friday when requested by the Owner. Technical support shall include, but not limited to the following:
a) Telephone Technical Support.
b) On-Site Visits: If resolution of a problem is not achieved via the Telephone Technical Support, an on-site visit and field report shall be required.

2. Operations and Maintenance Data:
a. Submit complete Installation, Operation and Maintenance Manuals, including, test reports, maintenance data and schedules, description of operation, and spare parts information.
b. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01 78 23, Operations and Maintenance Data.
3. Warranty Documentation:
a. General warranty.
b. Special warranties on materials and equipment.

D. Maintenance Material Submittals: Furnish the following:

1. Spare Parts:
    a. Spare parts list and recommended quantities.
    b. One set of bearings for each belt drive fan.
    c. One drive shaft for each belt drive fan.
    d. One set of belts for each belt drive fan.
2. Extra Stock Materials:
    a. Touch up paint for each unit.
3. Tools:
    a. Two sets of special tools, if any, required for normal operation and maintenance.
4. Spare parts, extra stock materials, and tools shall be packed in sturdy containers with clear indelible identification markings and shall be stored in a dry, warm location until transferred to the Owner at the conclusion of the Project.

## 1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading:
    1. Deliver materials to the Site to ensure uninterrupted progress of the Work.
    2. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete, in ample time to prevent delay of that Work.
    3. Comply with manufacturer's recommendations for rigging of equipment.

B. Storage and Protection:
    1. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.
    2. Store all equipment in covered storage off the ground and prevent condensation and in accordance with the manufacturer's recommendations for long-term storage.

C. Acceptance at Site:
    1. All boxes, crates and packages shall be inspected by Contractor upon delivery to the Site. Contractor shall notify Engineer, in writing, if any loss or damage exists to equipment or components. Replace lost equipment or components and repair damage to new condition, in accordance with manufacturer's instructions.

## 1.6 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive Owner of other rights or remedies Owner may otherwise have under the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under the Contract Documents. The obligations of Contractor under the Contract Documents shall not be limited in any way by the provisions of the specified special warranty.

B. Special Warranty on Materials and Equipment:

1. Provide manufacturer's written warranty, running to the benefit of Owner, agreeing to correct, or at option of Owner, remove or replace materials or equipment specified in this Section found to be defective during a period of 1 year after the date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 EQUIPMENT PERFORMANCE

A. Design Criteria:
   1. Design conditions shall be as indicated on the Equipment Schedule.
   2. Fans shall conform and be certified to UL 705.
   3. Fan bearings shall be rated for a minimum L-10 life of 100,000 hours at the fan's maximum operating speed in accordance with ABMA 9 or 11.
   4. Fans shall be balanced in accordance with AMCA Standard 204.

B. Performance Criteria:
   1. Minimum performance data for each unit shall be as indicated on the Equipment Schedule. Provided equipment shall not exceed scheduled total power.
   2. Fans shall be performance rated in accordance with AMCA Standards 210, 300, and 301.

### 2.2 DETAILS OF EQUIPMENT

A. Axial Fans
   1. Product and Manufacturer: Provide one of the following:
      a. Model A39, as manufactured by Hartzell.
      b. Or equal.
   2. Housing:
      a. Minimum 12-gauge continuously welded aluminum construction with 1-1/2 inch welded inlet and outlet flanges.
      b. Inspection door shall be provided for access to the fan wheel.
      c. Drive components shall be isolated for the airstream with a removable bearing cover and aerodynamic welded belt tunnel for belt drive units.
      d. Mounting brackets shall be welded to the outer housing to accommodate universal mounting feet for vertical or horizontal installation.
      e. Type 304 stainless steel fasteners.
   3. Propeller:
      a. Airfoil designed.
      b. Multiple bladed
      c. Cast aluminum.
      d. Propeller shall be retained on motor shaft utilizing split taper bushing.
      e. Adjustable pitch.

B. Fan Motors
   1. Motors shall be premium efficiency, totally enclosed fan cooled (TEFC) type. Where TEFC motors are not available from the manufacturer, provide open

drip proof (ODP) type with a letter from the manufacturer stating TEFC is not available.
2. Motors shall have a service factor of 1.15.
3. Motors shall be normal starting torque, normal slip, squirrel cage induction type. VFD driven motors shall be compatible for variable frequency drive operation and suitable to be applied in speed varying service without overheating.
4. Motors shall be of sufficient size so that there will be no overload on the motor above rated nameplate horsepower under any condition of operation imposed by the driven equipment.
5. Motors shall have Class F insulation with Class B temperature rise and be capable of carrying nameplate full load current plus service factor continuously without an injurious temperature rise in an ambient temperature of 40 degrees C.
6. Motor thrust bearings shall be adequate to carry continuous thrust loads under all conditions of operation imposed by the driven equipment.
7. Motors shall be in accordance with all current applicable standards of NEMA, IEEE, ABMA, NEC, and ANSI.
8. Locked rotor currents shall be as specified in NEMA Standards.
9. Provide lubrication of non-hygroscopic grease or oil type.
10. Provide automatic breather and drain for TEFC motor enclosures.
11. Provide integral overload protection on all single phase motors.
12. Provide severe duty type motors rated for chemical atmospheres where specified on the Equipment Schedule.

C. Belts and Drives
1. Fans shall be belt drive with adjustable sheaves or direct drive as shown on the Equipment Schedule.
2. Belts shall be oil and heat resistant, non-static type.
3. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized with a minimum 1.5 service factor of the installed motor horsepower.

## 2.3 ACCESSORIES

A. Structural Supports
1. Contractor shall provide and install all hangers, rods, supports, bolts, nuts, washers, inserts, and appurtenances as required to mount equipment where shown. All hangers, rods, supports, bolts, nuts, washers, inserts, and appurtenances shall conform to Section 23 05 29, Hangers and Supports for HVAC Ductwork, Piping, and Equipment.

B. Differential Pressure Switch
1. Product and Manufacturer: Provide one of the following:
a. Dwyer 1950G, as manufactured by Dwyer.
b. Neobits.
c. Or equal.
2. Vertical Plane Mounting.
3. NEMA 7 enclosure rating appropriate for Class 1 Div 1 environments.

4. Pressure range of each differential pressure switch shall be selected to match the corresponding duct system.
5. Pressure set point shall be field adjustable.

## 2.4 FINISHING

A. All surfaces shall be prepared, and coating systems applied and cured in strict accordance with the coating manufacturer's approved procedures. Primer coatings shall be selected for the specific material and application.

B. Primer coat and finish coat dry film thickness shall be applied to the required thickness as recommended by the coating manufacturer to provide maximum corrosion protection.

C. The equipment manufacturer shall furnish a written affidavit that the equipment has been prepared, primed, and coated in strict accordance with the coating manufacturer's procedures and at the coating manufacturer's facility.

D. All gears, bearing surfaces, machined surfaces, and other surfaces that are to remain unpainted shall receive a heavy application of grease or other rust-resistant coating. Maintain coating during shipping and storage until equipment is placed into operation.

## 2.5 CONTROLS

A. Sequence of Operations:
   1. Weaver Pump Station
      a. Supply Fan (WVR-SF-1)
         1) SF shall be controlled by an ON/OFF switch, provided by Electrical, set to run continuously.

## 2.6 IDENTIFICATION

A. All equipment and component identification shall be provided in accordance with Section 10 14 00, Signage.

B. All electrical wiring identification shall be provided in accordance with Section 26 05 53, Identification For Electrical Systems.

C. All electrical wiring shall be color-coded and labeled for simplified identification. Power wiring shall be coded per Owner standards.

## 2.7 SOURCE QUALITY CONTROL

A. Shop Tests:
   1. Fan Tests:
      a. Except as described below or otherwise approved by Engineer, test one fan of each size in accordance with AMCA Standard 210. Tests are not required for standard fans for which data on previously tested units of

equal design is available. Curves and other test data from units previously tested shall be submitted with shop test results prior to shipping equipment.

b. Test each fan for minimum three hours run-time, at the manufacturer's plant with the job or test motor. Vibration and temperature measurements shall be taken to determine its mechanical integrity. Vibration level shall be limited to a maximum of 1.25 mils. Temperature of bearing housing near the end of run time shall not exceed 215 degrees F under artificially created ambient temperature of 104 degrees F.

c. Each test shall be witnessed by a registered professional engineer, who may be an employee of fan manufacturer. The professional engineer shall certify that the required tests were performed, and sign and seal the results. Jurisdiction of professional engineer's registration, registration number, and name shall be on the seal. Equipment serial number shall also appear on test data for the fan.

2. Equipment shall be completely manufactured and pre-assembled in accordance with Reference Standards. Perform the following tests and inspections at factory before shipment:
   a. Tested and inspected for approval as a unit by Underwriters Laboratories Inc., UL Label or equal.
   b. Factory test equipment to ensure that the entire package has been properly fabricated and assembled, that all the controls function as specified herein and that the package meets the specified performance requirements including manufacturer's data report.
   c. Fan wheels and shafts shall be statically and dynamically balanced.

## PART 3 - EXECUTION

### 3.1 INSPECTION

A. Examine conditions under which materials and equipment will be installed and notify Engineer in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

B. Take field measurements where required prior to installation to ensure proper fitting of Work.

### 3.2 PREPARATION

A. Protection of Surrounding Areas/Surfaces:
   1. Openings and penetrations shall be capped to protect the building from outside conditions.
   2. Equipment shall be tightly covered and protected against dirt, water, and chemical or mechanical damage.

### 3.3 INSTALLATION

A. General:
   1. Install the equipment in accordance with the Contract Documents and by manufacturer's instructions and recommendations. Obtain written interpretation from Engineer in the event of conflict between manufacturer's instructions and recommendations and the Contract Documents.
   2. Install in accordance with Laws and Regulations.
   3. Do not modify structures to facilitate installation of equipment, unless approved in writing by Engineer.
   4. Installation to conform to requirements of all local and state codes.
   5. Curb mounted fans shall be provided with enough electrical wiring and conduit slack to allow the fan to be removed from the curb without disconnecting the electrical wiring at the fan.

B. Differential Pressure Switch
   1. To be installed in the dry well ductwork after the supply fan and before any air terminals. Units shall be calibrated to detect airflow and to send a signal when air flow is not detected. Coordinate with Instrumentation and Controls.

## 3.4 FIELD QUALITY CONTROL

A. Field Tests:
   1. After equipment installation is complete, Contractor and a qualified field service representative of unit manufacturer shall perform an operating test and a sound test of each unit and associated controls, in presence of Engineer. Equipment will pass the test when each unit and its controls are demonstrated to function correctly, and sound levels do not exceed maximum limits.
   2. Running Tests:
      a. Field-test each equipment together with its controls and appurtenances. Tests shall demonstrate to Engineer that each part and all parts together function in accordance with the Contract Documents. Provide all necessary testing equipment, labor, and appurtenances.
      b. Verify that equipment operates at design point as intended, that vibration limits are not excessive and beyond manufacturer's recommendations, and that equipment operates smoothly without excessive noise, temperature rise, or other defects, across entire range of operating curve. Verify that all controls work as intended in both manual and automatic mode. Successfully test-operate each equipment for at least (--1--) hours.
      c. If equipment does not comply with the Contract Documents and does not pass the tests, Contractor shall adjust, modify, and retest the equipment as often as necessary until tests are successfully passed.

B. Manufacturer's Services:
   1. Provide a qualified, factory-trained service person to perform the following:
      a. Instruct Contractor in installing equipment.
      b. After installation, inspect and adjust equipment, verify proper operation, and assist with field testing.
      c. Instruct operations and maintenance personnel in operation and maintenance of the equipment.
   2. Manufacturer's service person shall make visits to the Site as follows:

a. First visit shall be for instructing Contractor in proper equipment installation, and assisting in installing equipment. Minimum number of hours on-Site: 8 hours.
b. Second visit shall be for checking completed installation, start-up of system; and performing field testing. Minimum number of hours on-Site: 8 hours.
c. Third visit shall be to instruct operations and maintenance personnel.
    1) Furnish services of manufacturer's qualified, factory-trained specialists to instruct operations and maintenance personnel in recommended operation and maintenance of equipment.
    2) Training requirements, duration of instruction, and qualifications shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
    3) Number of hours on-Site shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
d. Technician shall revisit the Site as often as necessary until installation is acceptable.

3. All costs, including expenses for travel, lodging, meals and incidentals, and cost of travel time, for visits to the Site shall be included in the Contract Price.

## 3.5 ADJUSTING

A. Adjust all controls for proper settings.

B. While system is operable, balance all equipment to achieve design conditions.

## 3.6 CLEANING

A. Thoroughly clean all equipment and accessories prior to installation.

B. Remove all dirt, rust, dust, etc. from equipment and accessories after installation.

C. Remove and dispose of all debris and waste from the Site resulting from installation.

+ + END OF SECTION + +

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SECTION 23 34 06

NON-METALLIC HVAC FANS

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. Scope:
   1. Contractor shall provide all labor, materials, tools, equipment and incidentals as shown, specified and required to furnish and install non-metallic HVAC fans complete and operational with accessories.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the installation of items that must be installed with, or before, the non-metallic HVAC fans Work.

C. Related Sections:
   1. Section 10 14 00, Signage.
   2. Section 23 05 29, Hangers and Supports for HVAC Ductwork, Piping, and Equipment.
   3. Section 26 05 05, General Provisions for Electrical Systems.
   4. Section 26 05 53, Identification For Electrical Systems.
   5. Section 26 28 16.33, Disconnect Switches.

### 1.2 REFERENCES

A. Air Movement and Control Association International, Inc. (AMCA).
   1. AMCA Standard 204 – Balance Quality and Vibration Levels for Fans.
   2. AMCA Standard 210 – Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
   3. AMCA Standard 300 – Reverberant Room Method for Sound Testing of Fans.
   4. AMCA Standard 301 – Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

B. American Bearing Manufacturers Association (ABMA).
   1. ABMA 9 – Load Ratings and Fatigue Life for Ball Bearings.
   2. ABMA 11 – Load Ratings and Fatigue Life for Roller Bearings.

C. American Society for Testing and Materials (ASTM).
   1. ASTM E84 – Standard Test Method for Burning Characteristics of Building Materials.
   2. ASTM D4167 – Standard Specification for Fiber-Reinforced Plastic Fans and Blowers.

D. National Electrical Code (NEC).

E. National Fire Protection Association (NFPA).

1. NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems.
2. NFPA 91 – Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.

F. Underwriters Laboratories Inc. (UL).

## 1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer:
      a. Minimum of five years of experience producing substantially similar equipment and able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section regardless of the component manufacturer from a single non-metallic HVAC fan manufacturer.
   2. Require the non-metallic HVAC fan manufacturer to review and approve or to prepare all Shop Drawings and other submittals for all components furnished under this Section.
   3. All components shall be specifically constructed for the specified service conditions and shall be integrated into the overall equipment assembly by the non-metallic HVAC fan manufacturer.

C. Regulatory Requirements:
   1. National Electrical Code (NEC).
   2. National Fire Protection Association (NFPA).
   3. Underwriters Laboratories Inc. (UL).
   4. Local and State Building Codes and Ordinances.
   5. Permits: Contractor shall obtain and pay for all required permits, fees and inspections.

D. Certifications:
   1. Non-metallic HVAC fans shall bear an approved label with all the necessary identification marks, electrical data, and any necessary cautions as required by the National Electric Code.
   2. Non-metallic HVAC fans shall be AMCA certified.

## 1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Drawings showing fabrication methods, assembly, accessories, installation details, and wiring diagrams.
      b. Setting drawings, templates, and directions for the installation of roof/equipment curbs, anchor bolts, and other anchorages.
   2. Product Data:

a. Manufacturer's literature, illustrations, specifications, weight, dimensions, required clearances, materials of construction, and performance data for all equipment.
b. Complete component list.
c. Detailed description of each component.
d. Catalog cut sheets for each component.
e. Fan performance curves with operating points.
f. Standard and custom color selection charts for finishing system.
g. Lubricant Specification: Furnish lubricant specification for type and grade required for equipment furnished.
h. Deviations from Contract Documents. Any exceptions to the Contract Documents must be clearly defined. Contractor shall be responsible for any additional expenses that may occur due to any exception made.
i. Other technical data related to specified material and equipment as requested by Engineer.

3. Testing Plans, Procedures, and Testing Limitations:
   a. Plan for performing required shop testing.
   b. Plan for performing required field testing.

B. Informational Submittals: Submit the following:
1. Certificates:
   a. Certification of painting systems, in accordance with "Finishing" Article in this Section.
   b. Independent certification reports:
      1) UL Label or equal.
      2) AMCA certification.
2. Manufacturer Instructions:
   a. Instructions and recommendations for handling, storing, protecting the equipment.
   b. Installation Data.
   c. Instructions for handling, start-up, and troubleshooting.
3. Source Quality Control Submittals:
   a. Written report presenting results of required shop testing.
   b. Factory test reports.
4. Field Quality Control Submittals:
   a. Written report presenting results of required field testing.
5. Supplier Reports:
   a. Submit written report of results of each visit to Site by Supplier's service personnel, including purpose and time of visit, tasks performed, and results obtained. Submit within two days of completion of visit to the Site.
6. Qualifications Statements:
   a. Manufacturer, when requested by Engineer.

C. Closeout Submittals: Submit the following:
1. Maintenance Contracts:
   a. Service shall be provided by a factory-trained and certified equipment manufacturer's representative during the One Year Correction Period.

The equipment manufacturer's representative shall maintain all equipment furnished under this Section during the first year of operation.

b. Service provided shall include the following:
    1) Quarterly On-Site Service: Service intervals shall be quarterly for a minimum of one day of eight hours each quarter. The service duration shall be increased, as necessary by the equipment manufacturer's representative, taking into consideration the equipment service requirements and equipment size. Equipment manufacturer's representative shall indicate the service duration and service scope. Prior to the visits, the equipment manufacturer's representative shall contact the Owner and inquire as to problems encountered with the equipment. Service visits shall be scheduled at times agreeable to the Owner at least one week in advance. The quarterly service shall include, but not limited to the following:
        a) Provide manufacturer's recommended maintenance.
        b) Check all controls and components, and recalibrate or adjust as necessary.
        c) Perform necessary cleaning and services that are scheduled on a quarterly basis in accordance with the approved Operations and Maintenance Manuals. Provide all expendable materials, as necessary.
        d) Review and provide recommendations concerning Owner's operations.
        e) Replace or repair defective controls and components.
        f) Inspect control panels. Test control panel's indication lights and replace defective lights.
        g) Provide a detailed field report to the Owner.
    2) Technical Support: Technical support shall be provided between the hours of 8:00 AM and 4:00 PM local standard time, Monday through Friday when requested by the Owner. Technical support shall include, but not limited to the following:
        a) Telephone Technical Support.
        b) On-Site Visits: If resolution of a problem is not achieved via the Telephone Technical Support, an on-site visit and field report shall be required.

2. Operations and Maintenance Data:
    a. Submit complete Installation, Operation and Maintenance Manuals, including, test reports, maintenance data and schedules, description of operation, and spare parts information.
    b. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01 78 23, Operations and Maintenance Data.
3. Warranty Documentation:
    a. General warranty.
    b. Special warranties on materials and equipment.

D. Maintenance Material Submittals: Furnish the following:
    1. Spare Parts:
        a. Spare parts list and recommended quantities.

2. Tools:
    a. Two sets of special tools, if any, required for normal operation and maintenance.
3. Spare parts, extra stock materials, and tools shall be packed in sturdy containers with clear indelible identification markings and shall be stored in a dry, warm location until transferred to the Owner at the conclusion of the Project.

## 1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading:
1. Deliver materials to the Site to ensure uninterrupted progress of the Work.
2. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete, in ample time to prevent delay of that Work.
3. Comply with manufacturer's recommendations for rigging of equipment.

B. Storage and Protection:
1. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.
2. Store all equipment in covered storage off the ground and prevent condensation and in accordance with the manufacturer's recommendations for long-term storage.

C. Acceptance at Site:
1. All boxes, crates and packages shall be inspected by Contractor upon delivery to the Site. Contractor shall notify Engineer, in writing, if any loss or damage exists to equipment or components. Replace lost equipment or components and repair damage to new condition, in accordance with manufacturer's instructions.

## 1.6 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive Owner of other rights or remedies Owner may otherwise have under the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under the Contract Documents. The obligations of Contractor under the Contract Documents shall not be limited in any way by the provisions of the specified special warranty.

B. Special Warranty on Materials and Equipment:
1. Provide manufacturer's written warranty, running to the benefit of Owner, agreeing to correct, or at option of Owner, remove or replace materials or equipment specified in this Section found to be defective during a period of 1 year after the date of Substantial Completion.

# PART 2 - PRODUCTS

## 2.1 EQUIPMENT PERFORMANCE

A. Design Criteria:
   1. Design conditions shall be as indicated on the Equipment Schedule.
   2. Fan bearings shall be rated for a minimum L-10 life of 100,000 hours at the fan's maximum operating speed in accordance with ABMA 9 or 11.
   3. Fans shall be balanced in accordance with AMCA Standard 204.
   4. Fiberglass reinforced plastic fan construction shall conform to ASTM D4167.

B. Performance Criteria:
   1. Minimum performance data for each unit shall be as indicated on the Equipment Schedule. Provided equipment shall not exceed scheduled total power.
   2. Fans shall be performance rated in accordance with AMCA Standards 210, 300, and 301.

## 2.2 DETAILS OF EQUIPMENT

A. FRP Duct Axial Fan
   1. Product and Manufacturer: Provide one of the following:
      a. Series 29, as manufactured by Hartzell Fan Inc.
      b. Or equal.
   2. Housing:
      a. All fiberglass reinforced plastic surfaces shall be constructed of vinyl ester resin with 3 percent antimony trioxide to achieve Class I flame spread rate below 25 or equivalent and glass fiber.
      b. All structural parts in the air stream shall be fiberglass and resin.
      c. All internal hardware (air stream) shall be encapsulated Type 316 stainless steel.
      d. All external hardware (out of airstream) shall be Type 316 stainless steel.
      e. All air stream surfaces shall be provided with a synthetic veil and electrostatically conductive surface coating.
      f. Inspection door fastened with 316 stainless steel bot and gasketed for tight seal.
   3. Propeller:
      a. Air foiled designed.
      b. One piece construction.
      c. Cloth mat construction of solid fiberglass with aluminum insert molded into the hub for secure attachment to the shaft.
      d. Airfoil propeller shall not have an aerodynamic stall characteristic.

B. Fan Motors:
   1. Motors shall be premium efficiency, totally enclosed fan cooled (TEFC) type. Where TEFC motors are not available from the manufacturer, provide open drip proof (ODP) type with a letter from the manufacturer stating TEFC is not available.
   2. Motors shall have a service factor of 1.15.
   3. Motors shall be normal starting torque, normal slip, squirrel cage induction type. VFD driven motors shall be compatible for variable frequency drive operation and suitable to be applied in speed varying service without overheating.

4. Motors shall be of sufficient size so that there will be no overload on the motor above rated nameplate horsepower under any condition of operation imposed by the driven equipment.
5. Motors shall have Class F insulation with Class B temperature rise and be capable of carrying nameplate full load current plus service factor continuously without an injurious temperature rise in an ambient temperature of 40 degrees C.
6. Motor thrust bearings shall be adequate to carry continuous thrust loads under all conditions of operation imposed by the driven equipment.
7. Motors shall be in accordance with all current applicable standards of NEMA, IEEE, ABMA, NEC, and ANSI.
8. Locked rotor currents shall be as specified in NEMA Standards.
9. Provide lubrication of non-hygroscopic grease or oil type.
10. Provide automatic breather and drain for TEFC motor enclosures.
11. Two speed motors shall be provided with two windings per phase.
12. Provide integral overload protection on all single phase motors.
13. Provide motors rated for NFPA Class 1, Division 1 and/or Division 2 atmospheres where specified on the Equipment Schedule.

C. Belts and Drives:
1. Fans shall be belt drive with adjustable sheaves or direct drive as shown on the Equipment Schedule.
2. Belts shall be oil and heat resistant, non-static type.
3. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized with a minimum 1.5 service factor of the installed motor horsepower.

## 2.3 ACCESSORIES

A. Weather Cap:
1. For curb mounted supply duct axial fans.

B. Guide Vane Section:
1. As indicated on the Equipment Schedule of shown on the Drawings.

C. Prefabricated Roof Curbs:
1. Where specified on the Equipment Schedule or shown on the Drawings.
2. Construction:
   a. Weatherproof, fiberglass construction.
   b. Insulated with 1-1/2 inch minimum fiberglass sandwiched between inner and outer walls of curb.
   c. 12-inches minimum height measured from top of finished roofing system to top of pressure treated wood nailer strip. Contractor shall coordinate total height of curb with actual roofing system provided.
   d. Provide wood blocking and wood cant.
   e. Provide watertight flashing and counter flashing at curb.
3. Curb Gasket: Minimum 1-inch wide by 1/2-inch thick EPDM gasket cemented to curb top to provide air and water seal between curb and housing. Neoprene is not acceptable.

4. Fasteners: Type 316 stainless steel hardware.
5. Contractor shall furnish prefabricated roof curbs from the unit manufacturer.

D. Bird Screens:
1. For all roof mounted and wall mounted fans.
2. Provide 1-inch by 1-inch, 0.120-wire diameter, epoxy coated 316 stainless steel mesh screen securely anchored to housing.

E. Mounting Hardware:
1. Provide Type 316 stainless steel hardware for all fan installation.

F. Structural Supports:
1. Contractor shall provide and install all hangers, rods, supports, bolts, nuts, washers, inserts, and appurtenances as required to mount equipment where shown. All hangers, rods, supports, bolts, nuts, washers, inserts, and appurtenances shall conform to Section 23 05 29, Hangers and Supports for HVAC Ductwork, Piping, and Equipment.

## 2.4 FINISHING

A. All fiberglass surfaces shall be protected with a minimum 10 mil dry film thickness of chemical, flame, and ultraviolet resistant resin.

B. All gears, bearing surfaces, machined surfaces, and other surfaces that are to remain unpainted shall receive a heavy application of grease or other rust-resistant coating. Maintain coating during shipping and storage until equipment is placed into operation.

## 2.5 CONTROLS

A. Sequence of Operations:
1. Weaver:
a. Supply Fan (WVR-SF-2)
1) SF shall be controlled by an ON/OFF switch, provided by Electrical, set to run continuously.

## 2.6 IDENTIFICATION

A. All equipment and component identification shall be provided in accordance with Section 10 14 00, Signage.

B. All electrical wiring identification shall be provided in accordance with Section 26 05 53, Identification For Electrical Systems.

C. All electrical wiring shall be color-coded and labeled for simplified identification. Power wiring shall be coded per Owner standards.

## 2.7 SOURCE QUALITY CONTROL

A. Shop Tests:

1. Fan Tests:
    a. Except as described below or otherwise approved by Engineer, test one fan of each size in accordance with AMCA Standard 210. Tests are not required for standard fans for which data on previously tested units of equal design is available. Curves and other test data from units previously tested shall be submitted with shop test results prior to shipping equipment.
    b. Test each fan for minimum three hours run-time, at the manufacturer's plant with the job or test motor. Vibration and temperature measurements shall be taken to determine its mechanical integrity. Vibration level shall be limited to a maximum of 1.25 mils. Temperature of bearing housing near the end of run time shall not exceed 215 degrees F under artificially created ambient temperature of 104 degrees F.
    c. Each test shall be witnessed by a registered professional engineer, who may be an employee of fan manufacturer. The professional engineer shall certify that the required tests were performed, and sign and seal the results. Jurisdiction of professional engineer's registration, registration number, and name shall be on the seal. Equipment serial number shall also appear on test data for the fan.
2. Equipment shall be completely manufactured and pre-assembled in accordance with Reference Standards. Perform the following tests and inspections at factory before shipment:
    a. Tested and inspected for approval as a unit by Underwriters Laboratories Inc., UL Label or equal.
    b. Factory test equipment to ensure that the entire package has been properly fabricated and assembled, that all the controls function as specified herein and that the package meets the specified performance requirements including manufacturer's data report.
    c. Fan wheels and shafts shall be statically and dynamically balanced.

## PART 3 - EXECUTION

### 3.1 INSPECTION

A. Examine conditions under which materials and equipment will be installed and notify Engineer in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

B. Take field measurements where required prior to installation to ensure proper fitting of Work.

### 3.2 PREPARATION

A. Protection of Surrounding Areas/Surfaces:
    1. Openings and penetrations shall be capped to protect the building from outside conditions.

2. Equipment shall be tightly covered and protected against dirt, water, and chemical or mechanical damage.

## 3.3 INSTALLATION

A. General:
   1. Install the equipment in accordance with the Contract Documents and by manufacturer's instructions and recommendations. Obtain written interpretation from Engineer in the event of conflict between manufacturer's instructions and recommendations and the Contract Documents.
   2. Install in accordance with Laws and Regulations.
   3. Do not modify structures to facilitate installation of equipment, unless approved in writing by Engineer.
   4. Installation to conform to requirements of all local and state codes.
   5. Roof curb mounted fans shall be provided with enough electrical wiring and conduit slack to allow the fan to be removed from the curb without disconnecting the electrical wiring at the fan.

## 3.4 FIELD QUALITY CONTROL

A. Field Tests:
   1. After equipment installation is complete, Contractor and a qualified field service representative of unit manufacturer shall perform an operating test and a sound test of each unit and associated controls, in presence of Engineer. Equipment will pass the test when each unit and its controls are demonstrated to function correctly, and sound levels do not exceed maximum limits.
   2. Running Tests:
      a. Field-test each equipment together with its controls and appurtenances. Tests shall demonstrate to Engineer that each part and all parts together function in accordance with the Contract Documents. Provide all necessary testing equipment, labor, and appurtenances.
      b. Verify that equipment operates at design point as intended, that vibration limits are not excessive and beyond manufacturer's recommendations, and that equipment operates smoothly without excessive noise, temperature rise, or other defects, across entire range of operating curve. Verify that all controls work as intended in both manual and automatic mode. Successfully test-operate each equipment for at least 24 hours.
      c. If equipment does not comply with the Contract Documents and does not pass the tests, Contractor shall adjust, modify, and retest the equipment as often as necessary until tests are successfully passed.

B. Manufacturer's Services:
   1. Provide a qualified, factory-trained service person to perform the following:
      a. Instruct Contractor in installing equipment.
      b. After installation, inspect and adjust equipment, verify proper operation, and assist with field testing.
      c. Instruct operations and maintenance personnel in operation and maintenance of the equipment.
   2. Manufacturer's service person shall make visits to the Site as follows:

a. First visit shall be for instructing Contractor in proper equipment installation, and assisting in installing equipment. Minimum number of hours on-Site: 8 hours.
b. Second visit shall be for checking completed installation, start-up of system; and performing field testing. Minimum number of hours on-Site: 8 hours.
c. Third visit shall be to instruct operations and maintenance personnel.
    1) Furnish services of manufacturer's qualified, factory-trained specialists to instruct operations and maintenance personnel in recommended operation and maintenance of equipment.
    2) Training requirements, duration of instruction, and qualifications shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
    3) Number of hours on-Site shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
d. Technician shall revisit the Site as often as necessary until installation is acceptable.

3. All costs, including expenses for travel, lodging, meals and incidentals, and cost of travel time, for visits to the Site shall be included in the Contract Price.

## 3.5 ADJUSTING

A. Adjust all controls for proper settings.

B. While system is operable, balance all equipment to achieve design conditions.

## 3.6 CLEANING

A. Thoroughly clean all equipment and accessories prior to installation.

B. Remove all dirt, rust, dust, etc. from equipment and accessories after installation.

C. Remove and dispose of all debris and waste from the Site resulting from installation.

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SECTION 23 37 23

HVAC GRAVITY VENTILATORS

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. Scope:
   1. Contractor shall provide all labor, materials, tools, equipment and incidentals as shown, specified and required to furnish and install HVAC gravity ventilators complete and operational with accessories.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the installation of items that must be installed with, or before, the HVAC gravity ventilators Work.

C. Related Sections:
   1. Section 10 14 00, Signage.
   2. Section 23 05 29, Hangers and Supports for HVAC Ductwork, Piping, and Equipment.

### 1.2 REFERENCES

A. American Society for Testing and Materials (ASTM).
   1. ASTM B117 – Standard Practice for Operating Salt Spray (Fog) Apparatus.

### 1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer:
      a. Minimum of five years of experience producing substantially similar equipment and able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section regardless of the component manufacturer from a single HVAC gravity ventilator manufacturer.
   2. Require the HVAC gravity ventilator equipment manufacturer to review and approve or to prepare all Shop Drawings and other submittals for all components furnished under this Section.
   3. All components shall be specifically constructed for the specified service conditions and shall be integrated into the overall equipment assembly by the HVAC gravity ventilator equipment manufacturer.

C. Regulatory Requirements:
   1. National Electrical Code (NEC).
   2. National Fire Protection Association (NFPA).

3. Underwriters Laboratories Inc. (UL).
4. Local and State Building Codes and Ordinances.
5. Permits: Contractor shall obtain and pay for all required permits, fees and inspections.

## 1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Drawings showing fabrication methods, assembly, accessories, installation details, and diagrams.
      b. Setting drawings, templates, and directions for the installation of roof/equipment curbs, anchor bolts, and other anchorages.
   2. Product Data:
      a. Manufacturer's literature, illustrations, specifications, weight, dimensions, required clearances, materials of construction, and performance data for all equipment.
      b. Standard and custom color selection charts for finishing system.
      c. Deviations from Contract Documents. Any exceptions to the Contract Documents must be clearly defined. Contractor shall be responsible for any additional expenses that may occur due to any exception made.
      d. Other technical data related to specified material and equipment as requested by Engineer.

B. Informational Submittals: Submit the following:
   1. Certificates:
      a. Certification of painting systems, in accordance with "Finishing" Article in this Section.
      b. Copy of manufacturer's ISO 9001:2000 certificate.
   2. Manufacturer Instructions:
      a. Instructions and recommendations for handling, storing, protecting the equipment.
      b. Installation Data.
      c. Instructions for handling, start-up, and troubleshooting.
   3. Source Quality Control Submittals:
      a. Written report presenting results of required shop testing.
      b. Factory test reports.
   4. Supplier Reports:
      a. Submit written report of results of each visit to Site by Supplier's service personnel, including purpose and time of visit, tasks performed, and results obtained. Submit within two days of completion of visit to the Site.
   5. Qualifications Statements:
      a. Manufacturer, when requested by Engineer.

C. Closeout Submittals: Submit the following:
   1. Operations and Maintenance Data:

a. Submit complete Installation, Operation and Maintenance Manuals, including, test reports, maintenance data and schedules, description of operation, and spare parts information.
b. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01 78 23, Operations and Maintenance Data.

2. Warranty Documentation:
a. General warranty.
b. Special warranties on materials and equipment.

D. Maintenance Material Submittals: Furnish the following:
1. Spare Parts:
a. Spare parts list and recommended quantities.
b. One set of filters for each unit.
2. Extra Stock Materials:
a. Touch up paint for each unit.
3. Tools:
a. Two sets of special tools, if any, required for normal operation and maintenance.
4. Spare parts, extra stock materials, and tools shall be packed in sturdy containers with clear indelible identification markings and shall be stored in a dry, warm location until transferred to the Owner at the conclusion of the Project.

## 1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading:
1. Cover all openings into gear boxes with vapor inhibiting and water repellent material.
2. Deliver materials to the Site to ensure uninterrupted progress of the Work.
3. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete, in ample time to prevent delay of that Work.
4. Comply with manufacturer's recommendations for rigging of equipment.

B. Storage and Protection:
1. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.
2. Store all equipment in covered storage off the ground and prevent condensation and in accordance with the manufacturer's recommendations for long-term storage.

C. Acceptance at Site:
1. All boxes, crates and packages shall be inspected by Contractor upon delivery to the Site. Contractor shall notify Engineer, in writing, if any loss or damage exists to equipment or components. Replace lost equipment or components and repair damage to new condition, in accordance with manufacturer's instructions.

## 1.6 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive Owner of other rights or remedies Owner may otherwise have under the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under the Contract Documents. The obligations of Contractor under the Contract Documents shall not be limited in any way by the provisions of the specified special warranty.

B. Special Warranty on Materials and Equipment:
   1. Provide manufacturer's written warranty, running to the benefit of Owner, agreeing to correct, or at option of Owner, remove or replace materials or equipment specified in this Section found to be defective during a period of 1 year after the date of Substantial Completion.

# PART 2 - PRODUCTS

## 2.1 EQUIPMENT PERFORMANCE

A. Design Criteria:
   1. Design conditions shall be as indicated on the Equipment Schedule.

B. Performance Criteria:
   1. Minimum performance data for each unit shall be as indicated on the Equipment Schedule.

## 2.2 DETAILS OF EQUIPMENT

A. Dome Ventilators
   1. Product and Manufacturer: Provide one of the following:
      a. Model PR, as manufactured by Loren Cook Company.
      b. Model WCC, as manufactured by PennBarry.
      c. Or equal.
   2. Housing:
      a. Minimum 16-gauge spun aluminum construction reinforced with a rigid aluminum support structure.
      b. Baffle shall have a rolled bead for added strength.
      c. Type 316 stainless steel fasteners.
   3. Base:
      a. Aluminum construction with continuously welded curb cap corners.

## 2.3 ACCESSORIES

A. Prefabricated Roof Curbs
   1. Details of Construction:
      a. Weatherproof, continuous welded, minimum 14-gauge (0.064-inch), aluminum construction with pressure treated wood nailer.

b. Insulated with minimum 1-1/2 inch thick, 3 lb/ft$^3$ fiberglass sandwiched between inner and outer walls of curb.
c. 12-inches minimum height measured from top of finished roofing system to top of wood nailer. Contractor shall coordinate total height of curb with actual roofing system provided.
d. Provide wood blocking and wood cant as required.
e. Provide watertight flashing and counter flashing at curb.
f. Provide damper tray where backdraft damper is specified on the Equipment Schedule or shown on the Drawings.

2. Curb Gasket: Minimum 1-inch wide by 1/2-inch thick EPDM gasket cemented to curb top to provide air and water seal between curb and housing. Neoprene is not acceptable.
3. Ventilator to Curb and Curb to Roof Deck Fasteners: Type 316 stainless steel hardware.
4. Contractor shall furnish prefabricated roof curbs from the unit manufacturer.

B. Bird Screens
1. 3/4-inch by 3/4-inch expanded aluminum mesh screen securely anchored to housing.

C. Mounting Hardware
1. Provide Type 316 stainless steel hardware for all gravity ventilator installation.

D. Structural Supports
1. Contractor shall provide and install all hangers, rods, supports, bolts, nuts, washers, inserts, and appurtenances as required to mount equipment where shown. All hangers, rods, supports, bolts, nuts, washers, inserts, and appurtenances shall conform to Section 23 05 29, Hangers and Supports for HVAC Ductwork, Piping, and Equipment.

## 2.4 FINISHING

A. All surfaces shall be prepared, and coating systems applied and cured in strict accordance with the coating manufacturer's approved procedures. Primer coatings shall be selected for the specific material and application.

B. Primer coat and finish coat dry film thickness shall be applied to the required thickness as recommended by the coating manufacturer to provide maximum corrosion protection.

C. The equipment manufacturer shall furnish a written affidavit that the equipment has been prepared, primed, and coated in strict accordance with the coating manufacturer's procedures and at the coating manufacturer's facility.

D. All bearing surfaces, machined surfaces, and other surfaces that are to remain unpainted shall receive a heavy application of grease or other rust-resistant coating. Maintain coating during shipping and storage until equipment is placed into operation.

## 2.5 IDENTIFICATION

A. All equipment and component identification shall be provided in accordance with Section 10 14 00, Signage.

## 2.6 SOURCE QUALITY CONTROL

A. Shop Tests:
   1. Equipment shall be completely manufactured and pre-assembled in accordance with Reference Standards. Perform the following tests and inspections at factory before shipment:
      a. Factory test equipment to ensure that the entire package has been properly fabricated and assembled, that the package meets the specified performance requirements including manufacturer's data report.

# PART 3 - EXECUTION

## 3.1 INSPECTION

A. Examine conditions under which materials and equipment will be installed and notify Engineer in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

B. Take field measurements where required prior to installation to ensure proper fitting of Work.

## 3.2 PREPARATION

A. Protection of Surrounding Areas/Surfaces:
   1. Openings and penetrations shall be capped to protect the building from outside conditions.
   2. Equipment shall be tightly covered and protected against dirt, water, and chemical or mechanical damage.

## 3.3 INSTALLATION

A. General:
   1. Install the equipment in accordance with the Contract Documents and by manufacturer's instructions and recommendations. Obtain written interpretation from Engineer in the event of conflict between manufacturer's instructions and recommendations and the Contract Documents.
   2. Install in accordance with Laws and Regulations.
   3. Do not modify structures to facilitate installation of equipment, unless approved in writing by Engineer.
   4. Installation to conform to requirements of all local and state codes.

## 3.4 ADJUSTING

A. Adjust all controls for proper settings.

B. While system is operable, balance all equipment to achieve design conditions.

## 3.5 CLEANING

A. Thoroughly clean all equipment and accessories prior to installation.

B. Remove all dirt, rust, dust, etc. from equipment and accessories after installation.

C. Remove and dispose of all debris and waste from the Site resulting from installation.

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SECTION 23 82 39.43

ELECTRIC UNIT HEATERS

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. Scope:
   1. Contractor shall provide all labor, materials, tools, equipment and incidentals as shown, specified and required to furnish and install electric unit heaters complete and operational with accessories.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the installation of items that must be installed with, or before, the electric unit heaters Work.

C. Related Sections:
   1. Section 10 14 00, Signage.

### 1.2 REFERENCES

A. Air Movement and Control Association International, Inc. (AMCA).
   1. AMCA Standard 210 – Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.

B. Factory Mutual (FM).

C. National Electrical Code (NEC).

D. National Electrical Manufacturers Association (NEMA).

E. Underwriters Laboratories Inc. (UL).
   1. UL 873 – Temperature-Indicating and -Regulating Equipment.

### 1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer:
      a. Minimum of five years of experience producing substantially similar equipment and able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section regardless of the component manufacturer from a single electric unit heater manufacturer.

2. Require the electric unit heater manufacturer to review and approve or to prepare all Shop Drawings and other submittals for all components furnished under this Section.
3. All components shall be specifically constructed for the specified service conditions and shall be integrated into the overall equipment assembly by the electric unit heater manufacturer.

C. Regulatory Requirements:
1. Factory Mutual (FM).
2. National Electrical Code (NEC).
3. National Fire Protection Association (NFPA).
4. Underwriters Laboratories Inc. (UL).
5. Local and State Building Codes and Ordinances.
6. Permits: Contractor shall obtain and pay for all required permits, fees and inspections.

D. Certifications:
1. Electric unit heaters shall bear an approved label with all the necessary identification marks, electrical data, and any necessary cautions as required by the National Electric Code.

## 1.4 SUBMITTALS

A. Action Submittals: Submit the following:
1. Shop Drawings:
a. Drawings showing fabrication methods, assembly, accessories, installation details, and wiring diagrams.
2. Product Data:
a. Manufacturer's literature, illustrations, specifications, weight, dimensions, required clearances, materials of construction, and performance data for all equipment.
b. Complete component list.
c. Detailed description of each component.
d. Catalog cut sheets for each component.
e. Deviations from Contract Documents. Any exceptions to the Contract Documents must be clearly defined. Contractor shall be responsible for any additional expenses that may occur due to any exception made.
f. Other technical data related to specified material and equipment as requested by Engineer.

B. Informational Submittals: Submit the following:
1. Certificates:
a. Independent certification reports:
1) UL Label or equal.
2. Manufacturer Instructions:
a. Instructions and recommendations for handling, storing, protecting the equipment.
b. Installation Data.
c. Instructions for handling, start-up, and troubleshooting.

3. Source Quality Control Submittals:
    a. Written report presenting results of required shop testing.
    b. Factory test reports.
4. Field Quality Control Submittals:
    a. Written report presenting results of required field testing.
5. Supplier Reports:
    a. Submit written report of results of each visit to Site by Supplier's service personnel, including purpose and time of visit, tasks performed, and results obtained. Submit within two days of completion of visit to the Site.
6. Qualifications Statements:
    a. Manufacturer, when requested by Engineer.

C. Closeout Submittals: Submit the following:
1. Operations and Maintenance Data:
    a. Submit complete Installation, Operation and Maintenance Manuals, including, test reports, maintenance data and schedules, description of operation, and spare parts information.
    b. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01 78 23, Operations and Maintenance Data.

D. Maintenance Material Submittals: Furnish the following:
1. Spare Parts:
    a. Spare parts list and recommended quantities.
2. Tools:
    a. Two sets of special tools, if any, required for normal operation and maintenance.
3. Spare parts and tools shall be packed in sturdy containers with clear indelible identification markings and shall be stored in a dry, warm location until transferred to the Owner at the conclusion of the Project.

## 1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading:
1. Deliver materials to the Site to ensure uninterrupted progress of the Work.
2. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete, in ample time to prevent delay of that Work.
3. Comply with manufacturer's recommendations for rigging of equipment.

B. Storage and Protection:
1. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.
2. Store all equipment in covered storage off the ground and prevent condensation and in accordance with the manufacturer's recommendations for long-term storage.

C. Acceptance at Site:

1. All boxes, crates and packages shall be inspected by Contractor upon delivery to the Site. Contractor shall notify Engineer, in writing, if any loss or damage exists to equipment or components. Replace lost equipment or components and repair damage to new condition, in accordance with manufacturer's instructions.

## PART 2 - PRODUCTS

### 2.1 EQUIPMENT PERFORMANCE

A. Design Criteria:
   1. Design conditions shall be as indicated on the Equipment Schedule.
   2. All electric unit heaters shall be UL Listed.

B. Performance Criteria:
   1. Minimum performance data for each unit shall be as indicated on the Equipment Schedule. Provided equipment shall not exceed scheduled total power.

### 2.2 DETAILS OF EQUIPMENT

A. Horizontal Unit Heaters (Corrosive Environment)
   1. Product and Manufacturer: Provide one of the following:
      a. Model HD3D, as manufactured by Chromalox.
      b. Model TRIAD, as manufactured by INDEECO.
      c. Or equal.
   2. Casing:
      a. Minimum 20-gauge Type 304 stainless steel construction.
      b. Provided with Type 304 stainless steel universal wall swivel bracket and mounting hardware.
   3. Heating Elements:
      a. Type 316 stainless steel fin tubular element.
   4. Fans:
      a. Epoxy coated aluminum broad blade, axial-flow type design.
      b. Attached with rubber vibration isolators.
   5. Fan Motors:
      a. Totally-enclosed-fan-cooled epoxy coated enclosure.
      b. Permanently lubricated bearings.
      c. Integral thermal cutout.
   6. Louvers:
      a. Same material of construction as casing.
      b. Individually adjustable for downward, upward or straight air flow.
   7. Controls:
      a. NEMA 4X control enclosure.
      b. Sub-divided circuits with individual fuse protection for all heaters with a total current draw of 48 A or greater.
      c. Heavy duty magnetic contactors.
      d. Thermal cutout with automatic reset.

e. Integral 120 VAC control transformer.
f. Integral fan delay relay to dissipate residual heat build-up after shutdown.
g. Green power indication light.
h. Thermostats:
    1) Integral Type (factory installed):
        a) Thermostat Setpoint Range: 40 degrees F – 90 degrees F.
        b) Adjustable knob.

## 2.3 IDENTIFICATION

A. All equipment and component identification shall be provided in accordance with Section 10 14 00, Signage.

## 2.4 SOURCE QUALITY CONTROL

A. Shop Tests:
    1. Equipment shall be completely manufactured and pre-assembled in accordance with Reference Standards. Perform the following tests and inspections at factory before shipment:
        a. Tested and inspected for approval as a unit by Underwriters Laboratories Inc., UL Label or equal.
        b. Factory test equipment to ensure that the entire package has been properly fabricated and assembled, that all the controls function as specified herein and that the package meets the specified performance requirements including manufacturer's data report.
        c. Fan wheels and shafts shall be statically and dynamically balanced.

## 2.5 CONTROLS:

A. EUH shall be controlled by a space thermostat set to maintain the space at 55°F.

# PART 3 - EXECUTION

## 3.1 INSPECTION

A. Examine conditions under which materials and equipment will be installed and notify Engineer in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

B. Take field measurements where required prior to installation to ensure proper fitting of Work.

## 3.2 INSTALLATION

A. General:
    1. Install the equipment in accordance with the Contract Documents and by manufacturer's instructions and recommendations. Obtain written

interpretation from Engineer in the event of conflict between manufacturer's instructions and recommendations and the Contract Documents.
2. Install in accordance with Laws and Regulations.
3. Do not modify structures to facilitate installation of equipment, unless approved in writing by Engineer.
4. Installation to conform to requirements of all local and state codes.

## 3.3 FIELD QUALITY CONTROL

A. Field Tests:
   1. After equipment installation is complete, Contractor and a qualified field service representative of unit manufacturer shall perform an operating test of each unit and associated controls, in presence of Engineer. Equipment will pass the test when each unit and its controls are demonstrated to function correctly.
   2. Running Tests:
      a. Field-test each equipment together with its controls and appurtenances. Tests shall demonstrate to Engineer that each part and all parts together function in accordance with the Contract Documents. Provide all necessary testing equipment, labor, and appurtenances.
      b. Verify that equipment operates at design point as intended, that vibration limits are not excessive and beyond manufacturer's recommendations, and that equipment operates smoothly without excessive noise, temperature rise, or other defects, across entire range of operating curve. Verify that all controls work as intended. Successfully test-operate each equipment for at least 24 hours.
      c. If equipment does not comply with the Contract Documents and does not pass the tests, Contractor shall adjust, modify, and retest the equipment as often as necessary until tests are successfully passed.

B. Manufacturer's Services:
   1. Provide a qualified, factory-trained service person to perform the following:
      a. Instruct Contractor in installing equipment.
      b. After installation, inspect and adjust equipment, verify proper operation, and assist with field testing.
      c. Instruct operations and maintenance personnel in operation and maintenance of the equipment.
   2. Manufacturer's service person shall make visits to the Site as follows:
      a. First visit shall be for instructing Contractor in proper equipment installation, and assisting in installing equipment. Minimum number of hours on-Site: 8 hours.
      b. Second visit shall be for checking completed installation, start-up of system; and performing field testing. Minimum number of hours on-Site: 8 hours.
      c. Third visit shall be to instruct operations and maintenance personnel.
         1) Furnish services of manufacturer's qualified, factory-trained specialists to instruct operations and maintenance personnel in recommended operation and maintenance of equipment.

2) Training requirements, duration of instruction, and qualifications shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
3) Number of hours on-Site shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.

d. Technician shall revisit the Site as often as necessary until installation is acceptable.

3. All costs, including expenses for travel, lodging, meals and incidentals, and cost of travel time, for visits to the Site shall be included in the Contract Price.

## 3.4 ADJUSTING

A. Adjust all controls for proper settings.

B. Position unit as shown on the Drawings and adjust outlet louvers and diffusers for maximum throw.

## 3.5 CLEANING

A. Thoroughly clean all equipment and accessories prior to installation.

B. Remove all dirt, rust, dust, etc. from equipment and accessories after installation.

C. Remove and dispose of all debris and waste from the Site resulting from installation.

+ + END OF SECTION + +