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

Some of the paragraphs may be deleted. When deleting, do not renumber all the paragraphs. Simply leave the section number and title as is, delete the text, and add the words "Not Used".

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Moving and Conditioning Association, Inc. (AMCA): 203, Field Performance Measurement of Fan Systems.

2. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE): HVAC Applications Handbook.

3. Associated Air Balance Council (AABC): National Standards for Field Management and Instrumentation Total System Balance.

4. National Environmental Balancing Bureau (NEBB):

   a. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.

   b. Procedural Standards for Measuring Sound and Vibration.

5. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): HVAC Testing, Adjusting, and Balancing Manual.

1.2 SUBMITTALS

A. Informational Submittals:

1. Documentation of experience record of testing authority.

2. Documentation of current AABC or NEBB certifications for those technicians in responsible charge of the work under this Contract.

3. Submit detailed test and balance procedures, including test conditions for systems to be tested, prior to beginning the Work.

4. Written verification of calibration of testing and balancing equipment.

5. Balancing Log Report following completion of system adjustments including test results, adjustments, and rebalancing procedures.

1.3 QUALITY ASSURANCE

A. Air Balancing and Vibration Test Agency Qualifications: Have a proven record of at least five similar projects.

PART 2 PRODUCTS

2.1 MATERIALS

A. Provide materials, tools, test equipment, computers, and instrumentation required to complete the work included.

B. Test Hole Plugs: Plug test holes in ducts with plugs made for that purpose and replace any insulation removed to specified conditions.

PART 3 EXECUTION

3.1 GENERAL

A. Adjust and balance exhaust and supply air systems in accordance with standard procedures and recognized practices of the AABC or SMACNA.

3.2 AIR SYSTEM ADJUSTING AND BALANCING

A. Preparation: Prior to beginning the Work, perform the following activities:

1. Review Shop Drawings and installed system for adequate and accessible balancing devices and test points.

2. Recommend to Engineer dampers that need to be added or replaced in order to obtain proper air control.

3. Verify proper startup procedures have been completed on the system

4. Verify controls installation is complete and system is in stable operation under automatic control.

5. Verify test instruments have been calibrated to a recognized standard and are within Manufacturer's recommended calibration interval before beginning the Work.

B. General:

1. When adjustments are made to a portion of a fan system, reread other portions of that same system to determine effects imposed by adjustments. Readjust as necessary.

2. Lock and mark final positions of balancing dampers with permanent felt pen.

3. Adjust or correct fan and airflow measurements as required for actual cubic feet per minute measured at Site elevation.

C. Equipment Data: Collect the following data and included in final report:

1. Type of unit

2. Equipment identification number

3. Equipment nameplate data (including Manufacturer, model, size, type, and serial number)

4. Motor data (frame, horsepower (hp), volts, full load amps rate per minute (FLA rpm), and service factor)

5. Sheave Manufacturer, size, and bore

6. Sheave centerline distance and adjustment limits

7. Starter and motor overload protection data

8. Include changes made during course of system balancing.

D. Fan Systems:

1. Measure fan system performance in accordance with AMCA 203.

2. In each system at least one airpath from fan to final branch duct termination shall have dampers fully open. Achieve final air quantities by adjusting fan speed.

3. Adjust Fan Air Volumes:

   a. Adjust fan speeds and motor drives for required equipment air volumes, with allowable variation of plus 10 percent minus 0 percent.

   b. After final adjustments, do not operate motor above nameplate amperage on any phase.

   c. After final adjustments, do not operate fan above maximum rated speed.

   d. Perform airflow test readings under simulated or actual conditions.

4. Adjust outside air dampers, supply air dampers, exhaust air dampers, and motorized louvers for maximum and minimum air requirements.

5. Read and record static pressures at unit inlet and discharge, each filter set, coils, dampers, plenums, and mixing dual-duct or adjustable-volume boxes, on every supply, return, and exhaust fan for each test condition.

6. Read and record motor amperage on all phases for each test condition.

E. Air Outlets and Inlets:

1. In each system at least one air path from fan to final branch duct termination shall have dampers fully open.

2. Adjust air volumes on exhaust and supply diffusers and grilles, with allowable variation of plus or minus 10 percent.

3. Adjust diffusers and grilles for proper deflection, throw, and coverage. Eliminate drafts and noise where possible.

4. After final adjustments are made secure dampers to prevent movement and mark final positions with permanent felt pen.

F. Building Static Pressure: Measure building static pressure relative to outside in perimeter entrances during normal system conditions that would yield widest range in internal building pressure. Adjust accordingly to maintain minimum of 0.05-inch water column (WC) negative pressure in the room with entrance doors closed to outside.

3.3 FIELD QUALITY CONTROL

A. Vibration Performance Testing:

1. Upon completion of air system balance, perform vibration testing for all fans except restroom fan.

2. Take measurements at each bearing housing using calibrated electronic analyzer.

3. Measure velocity in direction parallel to rotating shaft, and in two directions perpendicular to shaft and to each other. Align measurement directions where possible to the horizontal and vertical planes.

4. Record log shall include equipment symbol or tag, location, identification, specified vibration velocity limits, and maximum measured velocity in each direction.

5. Notify Engineer if amplitude exceeds upper limit specified.

END OF SECTION

SECTION 23 09 13 - INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

Some of the paragraphs may be deleted. When deleting, do not renumber all the paragraphs. Simply leave the section number and title as is, delete the text, and add the words "Not Used".

PART 1 GENERAL

1.1 SUBMITTALS

A. Action Submittals: Manufacturer's product data, catalog cut sheets, installation instructions, and operations and maintenance information for specified products.

PART 2 PRODUCTS

2.1 PRODUCTS

A. General:

1. Specification applies to motorized control dampers and motorized control damper electric motor operators, except those furnished by Fan Manufacturer as packaged with fan equipment.

2. Dampers shall be two-position, parallel-blade type for open-close service.

2.2 MOTORIZED CONTROL DAMPERS (MCD)

A. Industrial Duty Motorized Dampers:

1. Frame: Frame: 5 inches by 1-inch by minimum 0.125-inch (127 millimeters by 25 millimeters by minimum 3.2 millimeters) 6063-T5 extruded aluminum hat-shaped channel, mounting flanges on both sides of frame, reinforced at corners.

2. Blades:

a. Style: Airfoil-shaped, single-piece.

b. Orientation: Horizontal or vertical with thrust washers, as indicated on Drawings.

c. Material: Heavy duty 6063-T5 extruded aluminum.

d. Width: Nominal 6 inches (152 millimeters).

3. Bearings: Molded synthetic sleeve, turning in extruded hole in frame.

4. Seals:

a. Blade Seals: Extruded neoprene type for ultra-low leakage from minus 72 to 275 degrees Fahrenheit (F) (minus 58 to 135 degrees Celsius (C)). Mechanically attached to blade edge.

b. Jamb Seals: Flexible metal compression type.

5. Linkage: Concealed in frame.

6. Axles:

    a. Minimum 1/2-inch (13 millimeters) diameter, hex-shaped, mechanically attached to blade.

    b. Material: Galvanized steel.

    c. Coordinate number of axles with the required number of actuators such that one axle is provided for each actuator. Multiple actuator on a single axle is not allowed.

7. Performance Data:

    a. Temperature Rating: Withstand minus 72 to 275 degrees F (minus 58 to 135 degrees C).

    b. Capacity: Demonstrate capacity of damper to withstand ventilation system operating conditions.

    c. Closed Position: Maximum pressure of 13 inches water gauge (w.g.) (3.2 kilopascal (kPa)) at 12-inch blade length (305-millimeter).

    d. Open Position: Maximum air velocity of 6,000 feet per minute (1,829 meter per minute).

    e. Leakage: Maximum 5.2 cubic feet per minute per square foot (0.6 cubic meter per minute per square meter) at 4 inches w.g. (1 kPa) for size 48 inches by 48 inches (1219 by 1219 millimeters).

    f. Pressure Drop: Maximum 0.03-inch w.g. (0.01 kPa) at 1,500 feet per minute (457 meters per minute) across 24-inch by 24-inch (610 by 610 millimeters) damper.

8. Accessories:

    a. Actuator: Refer to Article Motorized Control Damper Electric Motor Operators, for requirements.

    b. Flange Frame: 1-1/2 inches (38 millimeters), roll formed as part of frame, double configuration.

    c. Factory Sleeve: Minimum 20-gauge (1-millimeter) thickness, minimum 12-inch (305-millimeter) length.

    d. Duct Transition Connection: Size and shape to mate with ductwork as shown on Contract Drawings.

9. Manufacturers and Products:

    a. Ruskin; Model CD-50

    b. American Warming and Ventilating

c. TAMCO

2.3 MOTORIZED CONTROL DAMPER ELECTRIC MOTOR OPERATORS

A. General:

1. Provide electric operators for motorized dampers.

2. Contract Drawings show only one motor per motorized damper. Select actual quantity of motors required to operate each damper in accordance with size of damper provided.

3. Coordinate exact quantity of damper motors with electrical work including sizing of electrical power supplies to ensure that necessary power, wiring, and conduit is provided for complete installation.

B. Electric Damper Operators:

1. Performance:

a. 24-volt (V) direct current (dc), two-position

b. Spring return

c. Fail Position: Damper Open

2. Mounting: External side plate

3. Ample power to overcome friction of damper linkage and air pressure acting on damper blades.

4. Furnished with external adjustable stops to limit stroke.

5. Operating Torque:

a. Provide multiple independent damper sections, each with separate actuator, as needed to provide minimum of 120 percent of operating torque required by damper(s).

b. Required damper operating torque for actuator sizing calculations shall include friction of damper linkage and 1-inch water column (WC) air pressure on damper blades. Operating torque shall be minimum of 7-inch-pounds per square foot of damper area for parallel blade dampers.

6. Manufacturers:

a. Belimo

b. Siemens Building Technologies

c. Johnson Controls

d. Honeywell

2.4 ELECTRIC THERMOSTATS

A. Room Thermostat for Process Spaces:

1. Two-position electric type for cooling applications

2. Temperature Scale: 0 to 125 degrees F, dial type gauge

3. External adjustments

4. Adjustable sensitivity

5. Insulating back where exterior wall mounting is indicated

6. Locking wire protective guard

PART 3 EXECUTION

3.1 INSTALLATION

A. Motorized Control Dampers:

1. Install at motorized control damper locations indicated on Contract Drawings and in accordance with Manufacturer's instructions.

2. Install square and free from racking with blades running horizontally.

3. Bracing:

a. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure.

b. Install at every horizontal and vertical mullion.

B. Motorized Control Damper Electric Motor Operators:

1. Install quantity of electric operators required for each motorized damper, whether or not all motors are shown on Contract Drawings.

2. Install operators in accordance with Manufacturer's instructions.

3. Coordinate installation of operators with all trades to avoid interference with architectural features, structural members, and electrical lighting.

4. Electrical work shall include all wiring and conduit required for a complete installation of each motorized damper and shall be provided as part of the work of Division 26, Electrical.

3.2 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification:

1. Motorized Control Damper Schedule

2. HVAC Control Schedule

END OF SECTION

MOTORIZED CONTROL DAMPER SCHEDULE										
UNIT	LOCATION	UNIT	INTERLOCKED HVAC EQUIPMENT	TYPE	AIRFLOW (SCFM)	POWER SUPPLY (VOLTS) (PHASE)		FUNCTION	SIZE W x H (IN x IN)	COMMENTS
MCD-1	Chlorine Room	SUPPLY AIR INTAKE MOTORIZED DAMPER	EF-1	PARALLEL BLADE	450	24 DC	1	OPEN-CLOSE	36x22	FAILS OPEN UPON LOSS OF POWER. INTERLOCKED TO OPEN WHEN CHLORINE EXHAUST FAN IS ON.

NOTES:
1: EACH CONTROL DAMPER ACTUATOR UNIT MAY CONSIST OF MULTIPLE ACTUATORS AS REQUIRED TO MEET DAMPER TORQUE REQUIREMENTS.

HVAC CONTROL SCHEDULE					
UNIT	DESCRIPTION	INTERLOCKED EQUIPMENT	SPEED CONTROL	CONTROL DIAGRAM	CONTROL COMMENTS
EF-1	CHLORINE ROOM	MCD-1	CONSTANT	DRAWING ??	PROVIDE FAN WITH HAND/OFF/AUTO SWITCH AND INTERLOCKS TO SUPPLY AIR MOTORIZED DAMPER. IN HAND MODE: RELEASE SUPPLY AIR DAMPER TO OPEN, TURN ON EXHAUST FAN. FAN RUNS CONTINUOUSLY. IN OFF MODE: CLOSE SUPPLY AIR DAMPER, TURN OFF EXHAUST FAN, IN AUTO MODE ON/OFF SIGNAL IS PROVIDED FROM THERMOSTAT.
HEAT PUMP	WELL ROOM	NONE			UNIT IS CONTROLLED FROM THERMOSTAT.
NOTES:					

SECTION 23 31 13 - METAL DUCTS AND ACCESSORIES

Some of the paragraphs may be deleted. When deleting, do not renumber all the paragraphs. Simply leave the section number and title as is, delete the text, and add the words "Not Used".

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 500, Test Methods for Louvers, Dampers andShutters

2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook

3. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of PipingSystems

4. Association of the Nonwoven Fabrics Industry (INDA): IST 80.6, Water Resistance (HydrostaticPressure)

5. ASTM International(ASTM):

a. A36/A36M, Standard Specification for Carbon Structural Steel

b. A90/A90M, Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings

c. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

d. A176, Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip

e. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

f. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip

g. A568/A568M, Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for

h. A653/A653M, Standard Specifications for Steel Sheet, Zinc- Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

i. A700, Standard Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment

j. A924/A924M, Specification for General Requirements for Sheet Steel, Metallic-Coated by the Hot-Dip Process

k. A1008/A1008M, Standard Specification for Steel, Sheet, Cold- Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable

l. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High- Strength Low- Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

m. B209, Standard Specification for Aluminum and Aluminum- Alloy Sheet and Plate

n. C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method

o. C916, Standard Specification for Adhesives for Duct Thermal Insulation

p. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

q. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications

r. E84, Standard Test Method for Surface Burning Characteristics of Building Materials

s. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials

6. National Air Duct Cleaners Association (NADCA): General Specifications for the Cleaning of Commercial Heating, Ventilation and Air Conditioning Systems

7. National Fire Protection Association (NFPA):

   a. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems

   b. 90B Standard for the Installation of Warm Air Heating and Air- Conditioning Systems

   c. 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

   d. 255, Standard Method of Test of SurfaceBurning Characteristics of BuildingMaterials

   e. 259, Standard Test Method for Potential Heat of Building Materials

   f. 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

8. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):

   a. Duct Construction Standards

   b. Guidelines for Seismic Restraints of Mechanical Systems

   c. Fibrous Glass Duct Construction Standards

d. Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems

e. HVAC Air Duct Leakage Test Manual

9. Underwriters Laboratories Inc.(UL):

a. 181, Standard for Safety Factory-Made Air Ducts and Connectors

b. 214, Standard for Tests for Flame-Propagation of Fabrics and Films

c. 555, Standard for Safety Fire Dampers

d. 555S, Standard for Safety Smoke Dampers

1.2 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. CFM: cubic feet per minute

2. FPM: feet per minute

3. PCF: pounds per cubic foot

4. WC: water column

B. Sealing Requirements: For the purpose of duct systems sealing requirements specified in this section, the following definitions apply:

1. Seams: Joining of two longitudinally (in direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on perimeter are deemed to be joints.

2. Joints, duct surface connections including:

a. Girth joints

b. Branch and subbranch intersections

c. Duct collar tap-ins

d. Fitting subsections

e. Louver and air terminal connections to ducts

f. Access door and access panel frames and jambs

g. Duct, plenum, and casing abutments to building structures

1.3 SUBMITTALS

A. Action Submittals:

1. Ductwork Product Data: Manufacturer's product data including catalog sheets, diagrams, standard schematic drawings, installation instructions and details, details of materials, construction, dimensions of individual components, hangers and supports, seam and construction details, and finishes.

    a. Ductwork Accessories: Manufacturer's product data including catalog sheets, diagrams, standard schematic drawings, installation instructions and details, details of materials, construction, dimensions of individual components, and finishes.

B. Informational Submittals: Seismic anchorage and bracing drawings, cut sheets, and calculations as required by Section 01 88 15, Anchorage and Bracing.

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PART 2 PRODUCTS

2.1 GENERAL

A. Specified components of this ductwork system, including facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.

B. Ductwork material shall be aluminum or galvanized steel, minimum thickness 24-gauge.

C. Duct Sealants: Adhesives, cements, and sealants shall be as recommended by Duct Manufacturer for industrial applications.

D. Ductwork Interior Surfaces:

1. Smooth

2. No sheet metal parts, tabs, angles, or other items may project into air ducts, unless otherwise specified.

3. Seams and joints shall be external.

2.2 SHEET METAL MATERIALS

A. Construct supply and exhaust duct systems from aluminum or galvanized steel construct odor control duct systems from stainless steel as specified herein.

B. Galvanized Steel Ductwork:

1. Comply with ASTM A653/A653M and ASTM A924/924M.

2. Product Name: Steel Sheet, Zinc Coated (Galvanized Steel)

3. Sheet Designation: CS Type B

4. Applicable Specification: ASTMA653/A653M

5. (Zinc) Coating Designation: G90

6. Coating designation in accordance with Test Method A, ASTM A90/A90M and ASTM A924/A924M.

7. Provide mill-phosphatized finish for ducts exposed to view andfor ducts scheduled to be painted.

8. Provide sheet metal packaged and marked as specified in ASTM A700.

C. Aluminum Ductwork:

1. Comply with ASTM B209.

2. Aluminum Sheet: Alloy 3003-H14, unless indicated otherwise.

3. Aluminum Connectors and Bar Stock: Alloy 6061-T6, or equivalent.

D. Stainless Steel Ductwork:

1. Comply with ASTM A167, ASTM A176, ASTM A240/A240M, and ASTM A480/A480M.

2. Stainless Steel Sheet: Type 316/316L, unless indicated otherwise.

3. Gauge shall comply with SMACNA HVAC Industrial Duct Construction Standards manual, unless specified otherwise.

4. Finish: No. 2 B (cold-rolled, bright) finish. Welds shall be grinded smooth and passivated.

5. Longitudinal fusion welded butt seam, flanged fittings, and joints with all seams welded.

6. Elbows: Provide centerline equal to radius 1-1/2 times elbow diameter.

7. Fittings: Continuously welded along seams.

E. Exposed Ductwork: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains, discoloration, and other imperfections, including those which would impair painting.

F. Reinforcement Shapes and Plates: Unless otherwise indicated, provide reinforcements of same material as ductwork.

2.3 DUCT SEALING MATERIALS

A. General: The term sealant used here is not limited to materials of adhesive or mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics.

B. Adhesives, Cements, Sealant, and Installation Accessories: As recommended by Duct Manufacturer for application.

C. Solvent-Based Sealants:

1. Ultraviolet light resistant

2. Mildew resistant

3. Flashpoint: Greater than 70 degrees Fahrenheit (F), SETACC.

4. Manufacturers and Products:

a. Hardcast, Inc.; Versagrip 102

b. Rectorseal; AT-33

c. Childers CP-140

D. Water-Based Sealants:

1. Listed by Manufacturer as nonflammable in wet and dry state.

2. Manufacturers and Products:

a. Foster; Series 32

b. Childers; CP-145A, 146

c. Rectorseal; Airlok 181

E. Do not use silicone sealants at odor control ducting. Instead, utilize expanded Teflon (Gortex), or a Hypalon product.

2.4 DUCTWORK FASTENERS

A. General:

1. Rivets, bolts, or sheet metal screws.

2. Ductwork fasteners shall be same metal as duct being supported, unless otherwise noted.

B. Self-Drilling Screws:

1. Galvanized Steel Ductwork System: Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated carbon steel with zinc electroplated finish.

2. Aluminum Ductwork System:

a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Type 410 stainless steel, complete with bonded metal and fiber washer for dielectric separation.

b. Manufacturers:

1) DB Building Fasteners Inc., Santa Fe Springs, CA

2) Clark Craft Fasteners, Tonawanda, NY

3. Stainless Steel Ductwork System:

a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated, Type 410 stainless steel.

b. Manufacturers:

1) DB Building Fasteners Inc., Santa Fe Springs, CA

2) Clark Craft Fasteners, Tonawanda, NY

2.5 DUCTWORK PRESSURE CLASS

A. Construct duct systems to pressure classifications indicated as follows:

1. Supply Ducts: 3-inch WC

2. Return Ducts: 2-inch WC, negative pressure

3. Exhaust Ducts: 2-inch WC, negative pressure

B. Where no specific duct pressure designations are indicated in Specifications or on Drawings, 2-inch WC pressure class shall be basis of Contract.

2.6 RECTANGULAR DUCTWORK

A. Fabricate rectangular ducts in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless specified otherwise.

B. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 19 inches and larger and are 20-gauge or less, with more than 10 square feet of unbraced panel area, as indicated in SMACNA Manual, unless they are lined or are externallyinsulated.

2.7 RECTANGULAR DUCTWORK FITTINGS

A. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.

B. Elbows:

1. Fit square-turn elbows with vane siderails.

2. Shop fabricate double blade turning vanes of same material as ductwork.

3. Fabricate with equal inlet and outlet.

4. Rectangular radius elbows with inside radius of 3/4 of duct width in direction of turn.

5. Manufacturers and Products:

a. Elgen; All-Tight

b. Duro-Dyne; Type TR

2.8 RECTANGULAR DUCTWORK BRANCH CONNECTIONS

A. Branch duct connections to rectangular duct mains shall be made using factory fabricated fittings with spot welded tap to main duct connections or with factory fabricated, field installed taps, with spin-in or mechanical fastened tap to main duct connections.

2.9 RIGID ROUND DUCTWORK

A. Construct rigid round ducts in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless specified otherwise.

B. Basic Round Diameter: As used in this Article, is inside diameter of size of round duct.

C. Where space limitations prevent use of round duct or where shown on Drawings, provide ductwork of flat oval construction hydraulically equivalent to round ductwork.

D. Fabricate round ducts with spiral seam construction, except where diameters exceed 72 inches. Fabricate ducts having diameters greater than 72 inches with longitudinal butt-welded seams.

E. Ductwork seams of Snaplock type shall not be used.

2.10 RIGID ROUND DUCTWORK FITTINGS

A. Construct rigid round ductwork fittings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless otherwise specified.

B. 90-Degree Tees, Laterals, and Conical Tees: Fabricate to conform to SMACNA manual with metal thicknesses specified for longitudinal seam straight duct.

C. Diverging Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.

D. Elbows:

1. Fabricate in stamped (die-formed), pleated, or segmented (gored) construction 1-1/2 times elbow diameter. Two-piece segment elbows are not allowed, except with turning vanes.

2. Segmented Elbows: Fabricate with welded construction.

3. Round Elbows 8 Inches and Smaller:

a. Stamped elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees configuration.

b. Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 3-1/2 inches and 4-1/2 inches) elbows with segmented construction.

4. Round Elbows 9 Inches Through 14 Inches:

a. Segmented or pleated elbows for 30, 45, 60, and 90 degrees.

b. Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 9-1/2 inches and 10-1/2 inches) elbows with segmented construction.

2.11 DUCTWORK FLEXIBLE CONNECTIONS

A. General:

1. Factory fabricated metal-edged fabric flexible connectors for commercial or industrial applications.

2. Sheet metal permanently secured to fabric with double fabric fold, double metal crimp.

3. Comply with NFPA 90A and NFPA 90B requirements.

4. Airtight and waterproof.

B. Materials:

1. Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

2. Metal Edges: Construct from same material as ductwork, unless otherwise noted.

3. Fabric:

a. Comply with NFPA 701 or UL 214 (except Teflon coated)

b. Woven polyester or nylon

C. Construction:

1. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA Manual.

2. Standard Metal Edged Connectors: Strip of fabric 3 inches wide attached to two strips of 3-inch-wide sheet metal.

3. Wide Metal Edged Connectors: Strip of fabric 4 inches wide attached to two strips of 4-inch-wide sheet metal.

4. Extra Wide Metal Edged Connectors: Strip of fabric 6 inches wide attached to two strips of 6-inch-wide sheet metal.

D. Manufacturers:

1. Ductmate; PROflex, Commercial

2. Ventfabrics

3. Duro-Dyne

2.12 DUCTWORK HANGERS AND SUPPORTS

A. General:

1. Attachments, hangers, and supports for ductwork shall be in accordance with SMACNA Manual referenced for type of duct system being installed.

2. Duct hanging system shall be composed of three elements: upper attachment to building, hanger itself, and lower attachment to duct.

3. Wire hangers are not acceptable.

4. Hanger Spacing:

   a. Ducts Up to 60 inches in Largest Dimension: 10 feet, maximum.

   b. Ducts Over 61 inches in Largest Dimension: 8 feet, maximum.

B. Construction Materials: Supporting devices including, but not limited to, angles used for support and bracing, baseplates, rods, hangers, straps, screws, bolts shall be as follows:

1. Of same material as ductwork.

C. Building Attachments:

1. Concrete inserts, powder-actuated fasteners, or structural steel fasteners appropriate for building materials.

2. Do not use powder-actuated concrete fasteners for lightweight aggregate concrete or for slabs less than 4 inches thick.

3. Upper Attachment (Concrete):

   a. Drive pin fastener and expansion nail anchor may be used for ducts up to 18-inch maximum dimension.

   b. Threaded stud fastener may be used for ducts up to 36-inch maximum dimension.

   c. Concrete attachments shall be made of steel.

D. Duct Fasteners: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials and conforming to requirements of Article Ductwork Fasteners.

E. Trapeze and Riser Supports: Steel shapes conforming to ASTM A36/A36M, hot-dipped galvanized after fabrication.

2.13 DOUBLE WALL DUCTWORK

A. Provide double wall ductwork at odor control ductwork passing through the liquid phase odor control room where indicated on Drawings.

B. Materials of Constructions: Type 316 stainless steel for inner duct and type 304 stainless steel for outer duct.

C. Joining Method: Inner duct shall be joined using flanges and Vee Band with appropriate joint sealant suitable to withstand 10-percent sulfuric acid. Outer duct shall be joined using channel band with joint sealant. Both inner duct and outer duct joints shall be airtight.

D. Annular space to be air insulated.

E. Duct gauge thickness as specified herein.

F. Provide Manufacturer's standard gasketed flexible connection.

G. Manufacturers and Products:

1. Selkirk Model 12PS316/304

2. Or equal

2.14 MANUAL DAMPERS

A. Butterfly Manual Dampers:

1. Frame: 1-1/2-inch by 10-gauge.

2. Blade: 1/4-inch thick.

3. Elastomer type full circumference seal. Seal fastened to blade with bolted retainer ring.

4. Bearings: Grease lubricated ball bearings mounted outboard of frame with adjustable packing gland shaft seals.

5. Materials of construction: Type 316 stainless steel

6. Hand quadrant operator.

7. Maximum System Pressure: 20 inches WC.

8. Leakage: 1.1 cfm for 12-inch damper based on a pressure differential of 10 inches WC.

9. Damper Manufacturer and Model:

a. Ruskin CDR192

b. Greenheck HCDR-351

c. Or equal.

B. Aluminum, Counterbalanced, Standard Duty:

1. Fabrication:

a. Frame: 3 inches by minimum 0.09-inch, 6063-T5 extruded aluminum channel with front flange and rear flange and mitered corners.

b. Blades:

1) Style: Single piece, overlap frame

2) Action: Parallel

3) Material: Minimum 0.025-inch (0.6-millimeter) 6063-T5 formed aluminum.

4) Width: Maximum 6 inches (152 millimeters).

c. Bearings: Corrosion-resistant, long-life, synthetic, formed as single piece with axles.

d. Blade Seals: Extruded vinyl, mechanically attached to blade edge.

e. Linkage: Concealed in frame.

f. Axles: Corrosion-resistant, long-life, synthetic, locked to blade and formed as single piece with bearings.

g. Finish: Mill aluminum.

2. Performance Data:

a. Temperature Rating: Withstand minus 40 degrees to 200 degrees F (minus 40 degrees to 93 degrees Celsius (C)).

b. Maximum Back Pressure: 1-1/2-inch WC or 55 miles per hour (MPH) external wind.

c. Maximum Spot Air Velocity: 1,000 fpm (5 meters per second (mps)).

d. Operation of Blades:

1) Start to Open: 0.03-inch WC

2) Fully Open: 0.1-inch WC

e. Pressure Drop: Maximum 0.04-inch WC (0.01 kilopascal (kPa)) at 1,000 fpm (305 meters per minute (mpm)) through 24-inch by 24-inch (610-millimeter by 610-millimeter) damper.

3. Accessories:

a. Duct Transition Connection: Rectangular.

b. Factory Sleeve: Minimum 20-gauge (1.0-millimeter) thickness, minimum 12-inch (305-millimeter) length.

c. Screen:

1) Type: Bird

2) Location: Rear with sleeve

3) Material: Aluminum

4. Manufacturers and Products:

a. Ruskin; Model BD2A1

b. Or equal.

PART 3 EXECUTION

3.1 INSTALLATION

A. General:

1. Install sheet metal ductwork and flexible ductwork in accordance with SMACNA Manual, NFPA 90A, and NFPA 90B.

2. Install ductwork using Manufacturer's recommended adhesives, cement, sealant, and insulation accessories.

3. Joints and seams shall be sealedwatertight.

4. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth.

5. Interface Between Ductwork and Louvers: At locations where ductwork is connected to louver for either intake or exhaust purposes, ductwork shall be installed, sloped, and connected to louver so water entering ductwork system positively drains back to and out of louver.

B. Ductwork Location:

1. Locate ductwork runs vertically and horizontally, unless otherwise indicated.

2. Avoid diagonal runs whereverpossible.

3. As indicated by diagrams, details, and notations or, if not otherwise indicated, run ductwork in shortest route that does not obstruct usable space or block access for servicing building and equipment.

4. In general, install as close to bottom of structure as possible.

5. For ductwork concealed above ceiling, maximize clearance between bottom of ductwork and top of ceilingconstruction.

6. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

7. Ductwork that must transition and drop below piping or other ductwork shall be transitioned back to bottom of structure immediately adjacent to obstruction.

C. Penetrations:

1. Provide duct sleeves or prepared openings for duct mains, duct branches, and ducts passing through roofs, walls, and ceilings.

2. Clearances:

a. For uninsulated ducts, allow 1-inch clearance between duct and sleeve, except at grilles, registers, and diffusers.

b. For insulated ducts, allow 1-inch clearance between insulation and sleeve, except at grilles, registers, and diffusers.

3. Closure Collars:

a. Minimum 4 inches wide on each side of walls or floors where sleeves or prepared openings areinstalled.

b. Fit collars snugly around ducts and insulation.

c. Same gauge and material asduct.

d. Grind edges of collar smooth to preclude tearing or puncturing insulation covering or vaporbarrier.

e. Use fasteners with maximum 6-inch centers on collars.

4. Packing: Mineral fiber in spaces between sleeve or opening and duct or duct insulation.

D. Coordination with Other Trades:

1. Coordinate duct installation with installation of louvers, dampers, and ductwork accessories.

2. Ductwork shall be configured, positioned, and installed to permit installation of light fixtures as indicated on Drawings.

3. Coordinate ductwork layout to avoid interference with lighting, bridge crane, suspended ceiling, tanks, generator, electrical panels, and all process equipment.

3.2 RECTANGULAR DUCTWORK

A. General:

1. Where possible, install ductwork so seams and joints will not be cut for installation of grilles, registers, or ceilingoutlets.

2. If cutting of seams or joints is unavoidable, reinforce cut portion to original strength.

B. Low Pressure Taps:

1. Use bell mouth or conical fittings with integral locking quadrant damper. Spin-in fitting shall be sealed at duct-tap with a gasket or sealed with sealant as specified for medium pressure ductwork.

2. Determine location of spin-in after outlet location isdetermined.

3. Fitting shall be securely attached to shaft to prevent damper from rotating around shaft.

C. Fittings:

1. Use bell-mouth or conical tee fittings for round duct takeoffs from rectangular mains.

2. Use 45-degree entry fittings conforming to SMACNA requirements for rectangular takeoffs from rectangular or round mains.

3. Make offsets with maximum angle of 45 degrees.

4. Use fabricated fittings for changes in directions, changes in size and shape, and connections.

D. Rectangular Ductwork Transverse Joints:

1. Install each run with a minimum of joints.

2. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.

3. Mechanical Joint Option:

a. Construct transverse joints with Ductmate 25/35 duct connector systems, Ductmate W.D.C.I. Heavy/Lite duct connector systems, or Ductlok J/E duct connector system. Slip-on duct flange connectors shall have integral sealant pocket with permanently flexible sealant.

b. When using Ductmate W.D.C.I. Heavy/Lite system, construct ductwork in accordance with the Ductmate W.D.C.I. Heavy J and Light H Assembly Manual and Duct Construction Standards.

c. When using Ductlok J/E duct connector system, construct ductwork in accordance with Ductlok's Rectangular Duct Construction Manual for Low, Medium, and High Pressure.

d. For longitudinal seams, use Pittsburgh lock seam sealed internally with permanently elastic sealer such as Ductmate 5511M mastic.

e. Conform to SMACNA Class A sealing requirements.

3.3 RIGID ROUND OR OVAL DUCTWORK

A. General:

1. Round ductwork may be substituted in place of rectangular ductwork at locations approved by the Owner. Obtain written approval from the Owner prior to substituting round for rectangular ductwork.

2. Round ductwork shall be installed in lengths as long as possible to minimize joints.

B. Rigid Round or Oval Ductwork Joints:

1. Rigid round ductwork joints shall be in accordance with SMACNA, unless otherwise specified.

2. Single and Double Wall Supply and Return System Joints:

a. Less than 36 Inches: Slip coupling.

b. 36 Inches and Larger: Flanged connector, Van Stone, or welded companion flange type.

3. Single and Double Wall Exhaust and Return System Joints:

   a. Spiral Seam Duct: Welded flanged connector.

   b. Longitudinal Seam Duct: Van Stone flange connector.

3.4 FLEXIBLE CONNECTIONS

A. Flexible Collars and Connections:

1. Use between fans and ducts.

2. For round ducts, securely fasten flexible connections by zinc-coated steel clinch-type draw bands.

3. For rectangular ducts, lock flexible connections to metal collars.

3.5 DUCTWORK HANGERS AND SUPPORTS

A. Install ductwork with support systems in accordance with SMACNA Manual, unless otherwise noted.

B. Support ducts rigidly with suitable ties, braces, hangers, and anchors of type, which will hold ducts true-to-shape and to prevent buckling.

C. Install additional bracing on ductwork as required, to prevent ballooning or breathing.

D. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.

E. Support vertical ducts at maximum interval of 16 feet and at each floor.

F. Upper attachments to structures shall have allowable load not exceeding 1/4 of failure (proof test) load but are not limited to specific methods indicated.

G. In new construction, install concrete insert prior to placing concrete.

3.6 DUCT SEALING

A. Seal duct seams and joints as follows:

1. In accordance with SMACNA requirements.

B. If no specific duct sealing requirements are specified, requirements of SMACNA manual shall govern.

C. Provide additional duct sealing as required to comply with Article Ductwork Leakage Testing.

D. Seal all audible leaks.

3.7 DUCTWORK LEAKAGE TESTING

A. General:

1. Tests shall be conducted on completed ductworksystems.
2. Testing of partial installations or limited sections of ductwork will not be acceptable.
3. All ductwork leakage test procedures and results shall be submitted to Engineer for review.
4. Engineer shall retain the right to witness some or all ductwork leakage testing procedures.
5. Subcontractor shall notify Engineer in writing at least 5 working days prior to ductwork testing.

B. Leakage Criteria:

1. Assemble and install ductwork with maximum leakage limited as follows:
2. Odor Control Systems:
   a. Odor Control Ductwork:
      1) Operating Pressure: 0- to 2-inch WC.
         a) Allowable Leakage: 2 percent of design airflow.
      2) Operating Pressure: 3-inch and over WC.
         a) Allowable Leakage: 1 percent of design airflow.

C. Leakage Testing Method:

1. Subcontractor shall be responsible for providing all necessary test fans and calibrated measuring devices to accomplish ductwork leakage test and to demonstrate that ductwork systems leakage rate is less than maximum rate specified.
2. Pressure testing shall be accomplished using a pressure blower with a calibrated orifice and manometer.
3. Blower shall maintain SMACNA construction pressure classification during test.
4. Perform testing in accordance with procedures given in SMACNA HVAC Air Duct Leakage Test Manual.

3.8 BALANCING OF AIR SYSTEMS

A. Perform air balancing in accordance with requirements of Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

3.9 CLEANING

A. Ductwork shall be cleaned of rust, dust, and debris, both internally and externally, before placing in operation.

B. Before installing air outlets, use air handler to blow dry air through entire system at maximum attainable velocity. Provide temporary air filters for this operation.

C. If duct systems are found to contain construction debris at time of construction completion Subcontractor shall provide complete ductwork system cleaning in accordance with NADCA Standards.

END OF SECTION

SECTION 23 34 00 - HVAC FANS

Some of the paragraphs may be deleted. When deleting, do not renumber all the paragraphs. Simply leave the section number and title as is, delete the text, and add the words "Not Used".

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Acoustical Society of America (ASA)
2. Air Movement and Control Association International (AMCA)
3. American Bearing Manufacturers Association (ABMA)
4. ASTM International (ASTM)
5. National Electrical Manufacturers Association (NEMA)
6. Occupational Safety and Health Act (OSHA)
7. Underwriters Laboratories Inc. (UL)

1.2 SUBMITTALS

A. Action Submittals: Provide for all products specified, as follows:

1. Unit tag number or equipment identification as referenced in Contract Documents.
2. Manufacturer's name and model number.
3. Descriptive specifications, literature, and drawings.
4. Dimensions and weights.
5. Fan sound power level data (reference 10 to power minus 12 Watts) at design operating point.
6. Fan Curves:

a. Performance Curves Indicating:

1) Relationship of flow rate to static pressure for various fan speeds.
2) Brake horsepower curves.
3) Acceptable selection range (surge curves, maximum revolutions per minute, etc.).
4) Static pressure, capacity, horsepower demand, and overall efficiency required at the duty point, including drive losses.

7. Capacities and ratings.
8. Construction materials.
9. Fan type, size, class, drive arrangement, discharge, rotation, and bearings.
10. Wheel type, diameter, revolutions per minute, and tip speed.
11. Motor and Power Data: Refer to Section 26 20 00, Low Voltage AC Induction Motors.
12. Manufacturer's standard vibration isolation accessories.
13. Factory finish system.

B. Informational Submittals:

1. Recommended procedures for protection and handling of products prior to installation.
2. Manufacturer's installation instructions, including seismic anchorage and bracing requirements.
3. Factory test reports.
4. Operation and Maintenance Data.

Commented [JW1]: Input required from electrical/control subconsultant.

PART 2 PRODUCTS

2.1 FAN DRIVES

A. Drive assembly shall be sized for a minimum 140 percent of fan motor horsepower rating.

B. Shaft Guard:

1. Provide shaft guard for each fan and drive not housed in its own fan enclosure.
2. Shaft guards shall be easily removable and enclose entire drive assembly, meeting federal and OSHA requirements.
3. Guard faces shall be constructed of expanded metal having minimum 60 percent free area for ventilation.

2.2 FINISHES

A. Carbon Steel Parts: Factory finish as follows, unless indicated otherwise.

1. Parts cleaned and chemically pretreated with a phosphatizing process.
2. Alkyd enamel primer.
3. Air-dry enamel topcoat.

B. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.

C. Stainless Steel Parts: Finished smooth and left unpainted.

2.3 DIRECT DRIVE SIDWALL MOUNTED FANS

A. General Description:

1. Fan arrangement shall be exhaust, see Fan Schedule

2. Sidewall mounted applications

3. Maximum continuous operating temperature 130 Fahrenheit (F) (54.4 Celsius (C))

4. Each fan shall bear a permanently affixed manufacture's engraved metal nameplate containing the model number and individual serial number

B. Wheel:

1. Propeller shall be aluminum blade riveted to steel hub

2. A standard square key and set screw or tapered bushing shall lock the propeller to the motor shaft

3. Statically and dynamically balanced in accordance with AMCA Standard 204-05

4. The propeller and fan inlet will be matched and shall have precise running tolerances for maximum performance and operating efficiency

C. Motors:

1. Motor enclosures: Totally enclosed fan cooled

2. Motors are permanently lubricated, sleeve bearing type on sizes 8-12 and ball bearing type on sizes 14-24 to match with the fan load and furnished at 120 voltage and single phase

3. Accessible for maintenance

D. Drive Frame:

1. Drive frame assemblies and fan panels shall be galvanized steel.

2. Drive frame shall have welded wire or formed channels and fan panels shall have pre-punched mounting holes, formed flanges, and a deep formed one-piece inlet venturi.

E. Disconnect Switches:

1. NEMA rated: 4X

2. Positive electrical shut-off

3. Wired from fan motor to junction box

4. Dampers:

a. Type: Gravity

b. Prevents outside air from entering back into the building when fan is off

c. Balanced for minimal resistance to flow

d. Galvanized frames with pre-punched mounting holes

5. Dampers Guards:

a. Guard material: Galvanized

b. Shall completely enclose the damper or wall opening on the discharge side of the fan.

F. Manufacturers and Products:

1. Greenheck; SE1-12

2. Or equal

2.4 MOTORS

A. General:

1. Provide integral self-resetting overload protection on single-phase motors.

2. Motors shall not operate into service factor in any case.

B. Motor requirements shall be as follows, unless designated otherwise on Equipment Schedule:

1. Electrically commutated, permanent magnet type

2. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily

3. Solid state electronics

4. Shaft Type: Solid, carbon steel

5. Mounting: As required for fan arrangement

2.5 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component in a readily visible location. Plate shall bear 3/8-inch high engraved or die-stamped block type equipment identification number and letters indicated in this Specification and as shown on Drawings. All units shall include factory installed permanently attached nameplate displaying unit model and serial number.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install fans level and plumb.

B. Labeling: Label fans in accordance with Article Accessories.

C. Service Access: Locate units to provide access spaces required for motor, drive, bearing servicing, and fan shaft removal.

D. Connections:

1. Refer to Section 23 31 13, Metal Ducts and Accessories.

2. Isolate duct connections to fans.

3. Install ductwork adjacent to fans to allow proper service and maintenance.

3.2 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify blocking and bracing used during shipping are removed.

2. Verify fan is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.

3. Verify proper thermal-overload protection is installed in motors, starters, and disconnect switches.

4. Verify that cleaning and adjusting are complete.

5. Verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.

6. Verify lubrication for bearings and other moving parts.

7. Verify manual and automatic volume control and dampers in connected ductwork are in fully open position.

B. Performance Tests:

1. Starting Procedures:

a. Energize motor and adjust fan to indicated revolutions per minute.

b. Measure and record motor voltage and amperage.

2. Operational Test:

a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.

c. Test and adjust control safeties.

d. Replace damaged and malfunctioning controls and equipment.

3.3 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

B. On completion of installation, internally clean fans according to Manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

3.4 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this Specification:

1. Fan Schedule

END OF SECTION

UNIT	LOCATION	INTERLOCKED HVAC EQUIPMENT	AIRFLOW (SCFM)	ESP (IN WC)	DRIVE	MOTOR (HP)	FAN (RPM)	POWER SUPPLY (VOLTS)	(PHASE)	TYPE	STYLE	SPEED CONTROL	BASIS OF DESIGN MFR	BASIS OF DESIGN MODEL	COMMENTS
EF-1	Chlorine Room	MCD-090-0811A	450	0.15	DIRECT	1/20	1050	120	1	CENTRIFUGAL	Sidewall Mounted	CONSTANT	GREENHECK	SE1-12	
GENERAL NOTES:															